HARMSWORTH POPULAR SCIENCE

EDITED BY ARTHUR MEE

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MERCURY, THE ROMAN GOD OF TRAVELLERS AND MERCHANTS

CONTENTS OF VOLUME FIVE

A SUB-LORD OF THE HEAVENS

The Size, Density, Travels, Velocities, Satellites, and Spots of the Great Planet Jupiter

THE DISCOVERY OF THE SPEED OF LIGHT

After the asteroids we come to Jupiter, which is by far the greatest of the planets, and differs widely from those members of the sun's family we have already considered. The asteroids are interposed between two groups of planets, with four in each group; and while the individuals of each group are on the whole very like one another, the two groups are very unlike. Mercury, Venus, the Earth, and Mars are known as the terrestrial planets, from their general similarity to the earth. They are comparatively small, of dense structure, near together, and poor in satellites. They are aged planets, far advanced in the life-history to which all worlds appear destined.

Outside of these terrestrial planets are the asteroids, and outside these again is the group of four major planets, as they are called because of their great size. Jupiter, Saturn, Uranus, and Neptune are of huge dimensions as compared with the earth; they are also far less dense in structure, are situated much farther apart than the terrestrial planets, and some of them, at least, are richly provided with satellites. They are young planets, enveloped in dense mantles of cloud, and are still in the self-sustained stage, as distinguished from the sun-sustained stage. That is to say, the heat at their surface is their own heat and not the sun's heat. Indeed, they still combine some of the qualities of suns with the qualities of worlds. They are on the way from being more or less like our sun, to becoming more or less like our earth.

Although we thus group the four inner planets together as terrestrial planets, on account of their general similarity, there are, as we have seen, great differences among them. The same is true of the four major planets which we are about to study. There is similarity among them, but no sameness. Though all four are great, they still differ widely in size.

Perhaps Herschel's illustration of the dimensions and distances of the planets gives the clearest impression of the solar system, and of the relative proportions of its worlds. He imagines that a globe two feet in diameter is placed in the midst of a great level field. This globe represents the sun. He then proceeds: "Mercury will be represented by a *grain of mustard seed* on the circumference of a circle 164 feet in diameter for its orbit; Venus, a *pea* on a circle of 284 feet in diameter; the Earth, also a *pea* on a circle of 430 feet; Mars, a rather large *pin's head* on a circle of 654 feet; the asteroids, *grains of sand* in orbits of 1000 to 2000 feet; Jupiter, a *moderate-sized orange* in a circle nearly half a mile across; Saturn, a *small orange* on a circle of four-fifths of a mile; Uranus, a *full-sized cherry* or *small plum* upon the circumference of a circle more than a mile and a half across; and finally, Neptune, a *good-sized plum* on a circle about two miles and a half in diameter."

This picture assists the mind to realise in some degree how vast are the distances in space as compared with the dimensions of the planets, and how small and remote are these worlds which circle round the sun. But these distances are almost as nothing compared with stellar distances. Thus, Professor Young remarks that on Herschel's scale, as given above, the "nearest *star* would be on the opposite side of the globe, at the Antipodes, eight thousand miles away."

These major planets, then, are to the terrestrial planets as oranges and plums are to peas. Jupiter, the giant planet as he is often called, is larger than all the others put together. His mean diameter is 86,500 miles, which is nearly eleven times

the diameter of our globe; but this gives no adequate idea of his enormous size, for his superficial area is one hundred and nineteen times as great as that of the earth, and his volume exceeds that of the earth by one thousand three hundred times. On the other hand, as the density of the giant planet is less than one-fourth of the density of the earth, his mass is very small for so great a volume, and is only about three hundred and sixteen times that of the earth.

Strange Contrasts Between Jupiter and the Earth in Density and Movement

The force of gravity on the surface of Jupiter is 2·64 times as great as that on the earth's surface, so that a mass weighing one pound on earth would weigh two pounds ten ounces on Jupiter. This planet, with a diameter about one-tenth that of the sun, a circumference greater than the distance between the earth and the moon, and a density almost exactly the same as that of the sun, is obviously very different from our earth. The huge size and low density suggest that Jupiter is still far from the solid state.

The shape of Jupiter, like that of the earth, is a globe flattened at the Poles and bulging out at the equator, but the flattening and bulging are much greater in the case of Jupiter than in the case of the earth. As seen in the telescope, the outline of Jupiter is conspicuously elliptical, and measurements show that the Polar diameter of eighty-three thousand miles, and the equatorial diameter of eighty-eight thousand two hundred miles, are to one another as sixteen to seventeen. This wide departure from the spherical form is due to the great rapidity of the planet's spinning, to his huge size, and to the powerful centrifugal force which is consequently set up in equatorial regions. As a result of these same conditions, the force of gravity at the Poles of Jupiter exceeds the force of gravity at his equator in the proportion of six to five. It will be remembered that there is a similar difference between the gravitative force at the Poles and at the equator of the earth, but in this case the difference is only in the proportion of 191 to 190.

The Dizzy Spinning of Jupiter as He Travels Round the Sun in Twelve Years

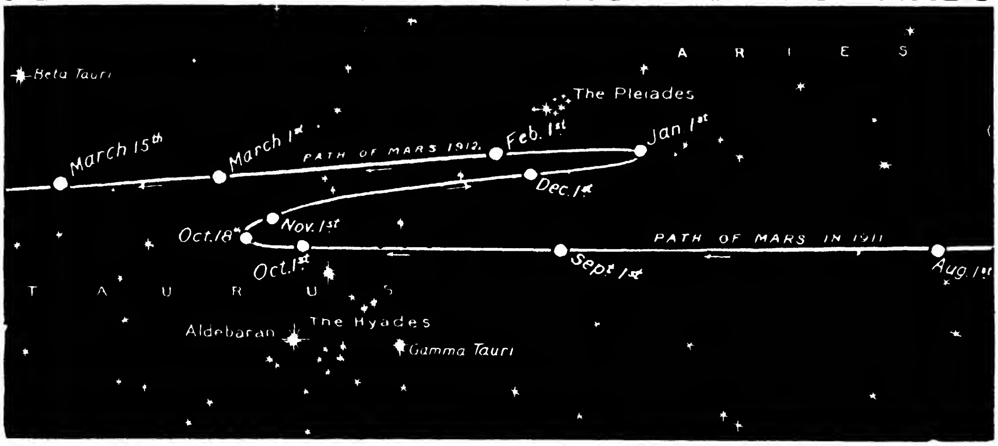
Jupiter travels round the sun at the rate of eight miles in a second, in a vast orbit which he completes in a little under twelve years. The earth, travelling round the sun in an orbit far within his, comes into line with him once in every three hundred and ninety-nine days. His distance from the earth varies from a maximum of 576,000,000 miles to a minimum of 369,000,000 miles, and his brightness at the nearest point is nearly three times his brightness when farthest away. The mean distance of Jupiter from the sun is 483,000,000 miles; but as his orbit has a certain eccentricity, his distance from the sun varies from 462,000,000 miles at the nearest point to 504,000,000 miles at the farthest point. The orbit of Jupiter is only very slightly inclined to the ecliptic —that is to say, to the plane of the earth's orbit, the degree of inclination being $1° 19'$. Owing to the movement of the earth round the sun, Jupiter appears, at intervals of about a year and a month, to stand still in his journey through the starry heavens, and even to retrace his steps for some distance, before going on again along the course which it takes him nearly twelve years to accomplish.

In strong contrast to the long period of his orbital revolutions, Jupiter rotates on his own axis with stupendous velocity, so that his day, corresponding to our day of twenty-four hours, is completed in about nine hours and fifty-four minutes, giving to every point on his surface about five hours from sunrise to sunset and five from sunset to sunrise.

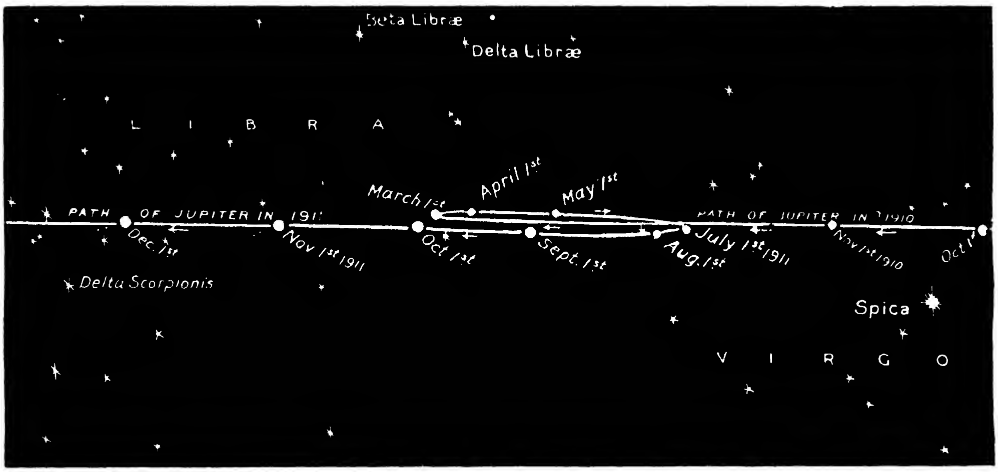
The Different Paces of the Planet's Different Envelopes

But this planet, or at any rate his visible surface, does not rotate all as one solid body. Jupiter is in this respect, as in others, like the sun. His equatorial regions travel round more quickly than the regions of higher latitude, the former completing the circuit of day and night in nine hours and fifty minutes, while the parts which are nearer the Pole take seven minutes longer to perform the same circuit. Moreover, different spots in the same latitudes travel with somewhat different speeds, and even the same marking has been observed with great exactness to vary from time to time the rapidity of its rotation. All these facts show that what we see of Jupiter is not a solid body, and, indeed, it is very doubtful whether he has any solid body at all. The axis about which Jupiter rotates is very nearly vertical to the plane of his orbit, being inclined to it by only three degrees. There are, therefore, no seasons; but Jupiter is still, as regards heat, in the self-sustained stage, so that the sun's effects are excluded from his surface, and there would therefore be no seasons even if his axis were inclined like the axis of the earth.

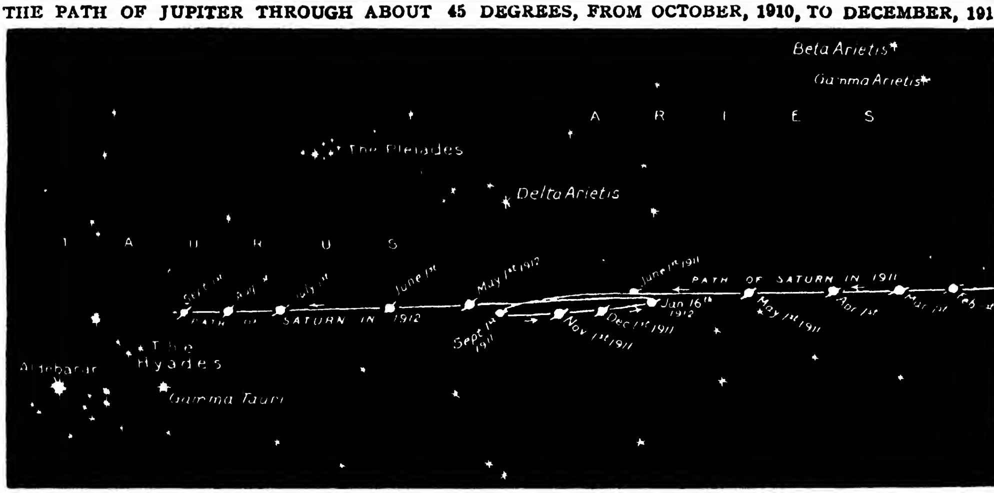
PLANETS THAT SEEM TO MOVE BACKWARDS



THE PATH OF MARS THROUGH ABOUT 45 DEGREES OF THE HEAVENS, FROM AUGUST, 1911, TO MARCH, 1912



THE PATH OF JUPITER THROUGH ABOUT 45 DEGREES, FROM OCTOBER, 1910, TO DECEMBER, 1912



THE PATH OF SATURN THROUGH ABOUT 40 DEGREES, FROM FEBRUARY, 1911, TO SEPTEMBER, 1912

Each of these star-maps represents an area of the sky about 45 degrees wide, or a band about one quarter across the dome of the sky. By comparing the distances traversed by each planet with the times occupied, it will be seen that the speed and the amount of retrograde movement diminish relatively to the distance of each planet from the earth. This fact gave the early astronomers an idea of their relative distances. It is important to note that these pictures do not show the real motion of the planets, but the apparent motion, which is due to the combined motion of the earth and the planet in question. This motion was ingeniously explained in the ancient Ptolemaic system by what were called epicycles, which are illustrated on page 903 of POPULAR SCIENCE.

Jupiter has no fewer than eight moons, which circle around him. Four of them are of very recent discovery, but the four larger satellites were the first objects to be discovered after the invention of the telescope. It was on January 7, 1610, that Galileo turned his new instrument upon the giant planet, and saw that he was attended by four little stars which moved to one side of Jupiter and then to the other side, and passed before and behind him, giving the impression of a solar system in miniature. Galileo named them the "Medicean stars," after his noble patron, Cosmo de Medici. There was not a little annoyance and incredulity among scholastic philosophers when Galileo thus added to the number of the heavenly bodies, and upset theories which had satisfied everyone for a long time.

The Moons and Recently Found Moonlets of the Giant Planet

Until 1892 these four moons which Galileo discovered were regarded as the only satellites of Jupiter. They were named, in order of their nearness to the planet, Io, Europa, Ganymede, and Callisto. In size the two inner ones, Io and Europa, are not very different from our own moon, but the diameters of Ganymede and Callisto are nearly twice her diameter. Their distances from Jupiter are respectively 260,000 miles, 414,000 miles, 661,000 miles, and 1,162,000 miles. Taking them in the same order, the periods of their revolutions, reckoned in days of Jupiter, are about four and a quarter days, eight and a half days, seventeen and a quarter days, and forty and a half days.

Although these four greater moons would be of considerable size from the terrestrial point of view, they are very minute as compared with the planet to which they belong. Ganymede, for instance, has nearly twice the volume of the planet Mercury, and about two-thirds of the volume of the planet Mars, yet the volume of the four major satellites put together is little more than one-eight-thousandth of the volume of Jupiter.

The Orbits and Occultations of Jupiter's Little Retinue of Moons

The orbits in which the satellites move are in the plane of the equator of Jupiter, which is also the plane of the ecliptic or orbit of the earth. They appear, therefore, as tiny stars lying along a horizontal line which passes through the centre of the planet; and the system of Jupiter and the four moons of Galileo cover a space in the sky about equal to two-thirds of the apparent diameter of our moon. These moons may be seen in transit over the face of Jupiter, and disappear, or are occulted, when they pass behind his disc. They are eclipsed when they pass into the huge shadow which extends outward from the planet away from the sun; and from the fact that they become invisible when eclipsed it is unlikely that Jupiter, as some have supposed, throws out any light of his own. Further, they eclipse Jupiter himself, and may be seen to do so. Not that their tiny forms can throw the giant planet into darkness, but their shadows can be seen travelling over his face as minute black spots. From time to time it happens that all four of the Medicean stars become invisible simultaneously, some being eclipsed, and others being occulted or in transit over the planet's face.

These moons, like Jupiter himself, receive, area for area, only one-twenty-seventh of the sunlight which is received on earth, and therefore cannot have much importance as luminaries. Otherwise, they appear to be more efficient reflectors than our moon, with the exception of Callisto, which is curiously dark.

The Puzzling Variation in the Light of Jupiter's Moons

The four moons not only differ considerably among themselves in respect of brightness, but, as Galileo himself discovered, they vary individually from time to time in the amount of light which they reflect. There are regular and also irregular variations. Callisto appears to change in reflective power according to the position which it holds in its orbit, and is therefore believed to turn as our moon does, keeping always one face to its planet, and so turning surfaces of different degrees of whiteness and blackness in regular alternation towards the sun. The very puzzling irregular variations in luminosity have been noticed by many astronomers since Galileo, and admit of little doubt, although some of the most skilful observers with photometric instruments have failed to obtain reliable evidence of irregular changes in brilliancy.

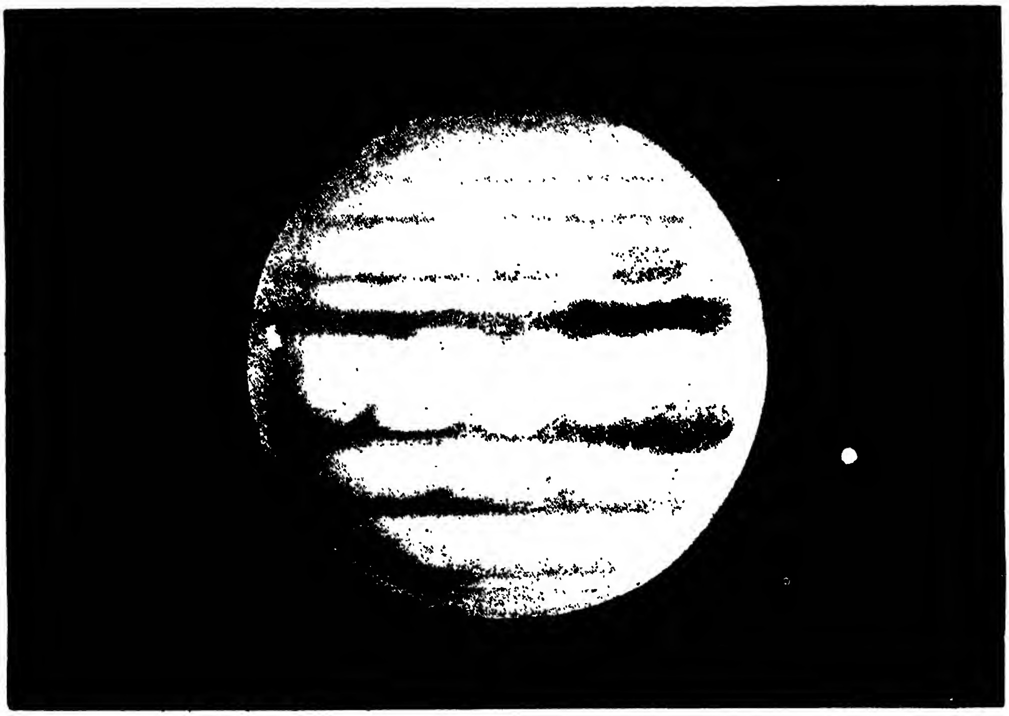
Definite markings have been made out, by telescopes of high power, upon the four greater satellites of Jupiter. Those upon the surface of Ganymede are specially interesting, because they appear to resemble the canal markings upon the planet Mars. Ice-caps, recognised by their great brilliancy, have been distinguished upon Callisto and Ganymede. Io, the innermost

of the four, has in general a fairly dull surface, but has a broad zone of light colour round its equator. These moons are, however, at so great a distance from the earth that only the largest markings upon them can be made out at all, and even these cannot be seen with great certainty. All four of the moons of Jupiter can be seen with an ordinary field-glass as specks of light, but it takes a powerful telescope to show their discs clearly.

From 1610 until 1892, only these four moons were known, but since then their number has been doubled. In September 1892, Professor Barnard, at Lick Observatory, discovered a fifth very small moon, having a diameter of only about one hundred miles, revolving very close to Jupiter within the orbit of Io, and completing its orbit in somewhat less than twelve hours. This satellite, from its proximity to the brilliant planet, is extremely difficult to observe. A few years later, in 1904, Professor Perrine, at the same observatory, discovered by means of photography two minute satellites even smaller than that of Professor Barnard, and moving in orbits outside those of Galileo's moons. Finally, in 1908, Mr. Melotte, of Greenwich Observatory, discovered by photography an eighth satellite, very small, very distant from Jupiter, and moving in an extremely eccentric orbit. But the most remarkable quality of this eighth satellite is that it is retrograde—that is to say, it revolves in the contrary direction to the revolution of all the others.

This retrograde movement is of great importance, because, as we shall see in a later chapter, most far-reaching astronomical theories have been based upon it.

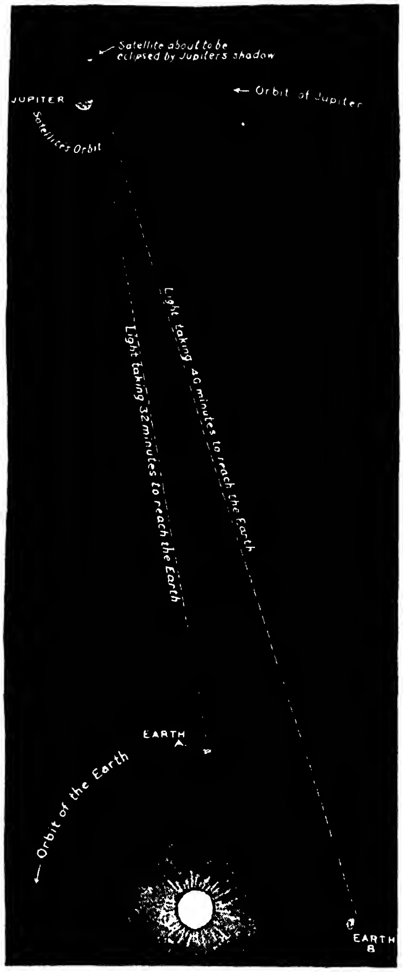
It is by no means unlikely that we may yet hear of additions to the number of Jupiter's moons. This prodigious planet, which has even his own family of comets and rules by his influence the whole zone in which lie the orbits of the asteroids, may well have many minute bodies circulating about him.



JUPITER, SHOWING ITS BELTS OF CLOUDS, THE OVAL RED SPOT ABOUT 1881, AND A SATELLITE WITH THE SHADOW THAT IT CASTS ON THE PLANET

We must not leave the subject of Jupiter's satellites without referring to the very interesting way in which their movements were formerly made to give evidence with regard to the speed of light. There are now more exact ways of determining the velocity of light by laboratory experiments, but the eclipses of Jupiter's moons were the phenomena which first showed that light travels at a speed of 186,000 miles in a second.

Roemer, a Danish astronomer, was the first, in 1675, to explain a remarkable fact with regard to these eclipses. The orbits and velocities of Galileo's moons being known with great exactness, it was possible to predict the moments at which eclipses, transits, and occultations of these moons ought to take place. It was found, however, that in proportion as Jupiter, in the course of his orbit, departed further from the earth, in the same proportion the eclipses, transits, and occultations of Jupiter's moons were retarded beyond the times at which it had been calculated that they ought to occur. On the other hand, the gradual approach of Jupiter towards the earth was accompanied by a gradual return to punctuality of these eclipses and other phenomena. So vast is the range of the planet's movements that when it is farthest from us the eclipses are more than sixteen minutes behind their time. Roemer saw that these changes were perfectly intelligible if light, instead of being an instantaneous flash, were a movement of great velocity, yet still taking some appreciable and measurable time to accomplish a given distance. He proved his case beyond question, yet his conclusions were rejected until many years after his death.



HOW THE VELOCITY OF LIGHT WAS FIRST DISCOVERED

By observing the phenomena of Jupiter's satellites Roemer noticed that anticipated eclipses did not occur to time, but that when the earth was at B, for instance, the eclipse was eight minutes later than when at A, or nearly 100 million miles nearer to Jupiter. This diagram also shows the relative distances of the earth and Jupiter from the sun.

It is not at all unlikely that the satellites of Jupiter have an atmosphere; and Flammarion, who has given much study to these moons, believes that he has evidence of its existence. Speculating in his curiously enthusiastic way, he remarks that "it is highly probable that they are now inhabited, and that they form the earliest abodes of life in the Jovian system." And again: "The magnificence of the spectacle presented by Jupiter himself to the inhabitants of the satellites is worthy of our attention." Indeed, if the little moon which Professor Barnard discovered be inhabited, its people see Jupiter as a vast disc, whose diameter extends more than half the distance from the zenith to the horizon.

This disc of Jupiter, moreover, is an extremely good reflector, returning over 60 per cent of the light which it receives. Like the disc of the sun, Jupiter is brightest towards his centre, and darkest towards his edge, whereas the terrestrial planets—Mercury, Venus, and Mars—are apparently brighter towards the edge than in the centre. Whether this quality, in which Jupiter resembles the sun, is due to his light being partially his own glow and only partially reflected sunlight, is a difficult question. The giant planet does appear to glow, but the light thus produced does not amount to much, because it is insufficient to light up the moons when they are eclipsed. Professor Young suggests that a nearly transparent atmosphere overlying a uniformly reflecting surface would produce this effect of a darkened edge.

When seen through a powerful telescope, Jupiter becomes a beautiful spectacle of form and colour. It is obvious at once that we are not looking upon the face of a solid world, but upon an immense ocean of cloud, with visions of a glowing interior of dusky cherry-red. Brown, maroon, dark green, and purple colours diversify the picture. The markings are inconstant, and shift their places and relations, showing that they are only cloud forms; but, on the other hand, considering that they are nothing more substantial than clouds, they have extraordinary stability. The main structure of the markings consists in belts parallel to the equator; but as these are whirled round before the eye in the swift rotation of the

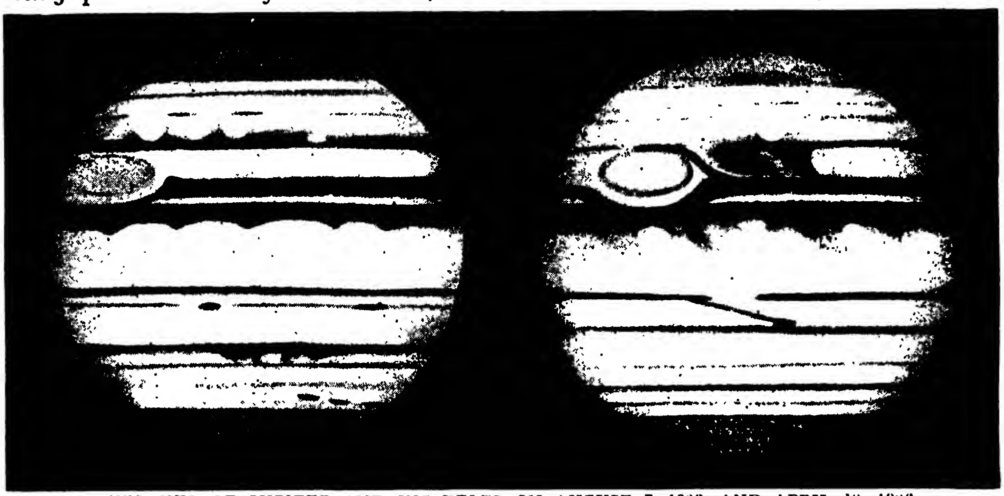
planet, they are seen to be irregular and shifting. The entire scene suggests clouds at the first glance; the wavy, streaky alternations of dark and light, lying in the horizontal direction, are like the stratified clouds often seen in the west at sunset. The most constant features are two broad bands of dark colour, one on each side of the equator, in the position of the terrestrial belts of trade wind. The brilliantly reflecting bands of light colour, lying between, and north and south of the darker zones, are certainly clouds, reflecting light in exactly the proportion with which our clouds do.

Whether, as is most probable, they are clouds of water droplets, or, as they may very well be, clouds of some other kind, has not yet been determined. But we know that they are produced by vapour distilled from Jupiter's surface by his own heat, and condensed into droplets by the chill of outer space. They are not produced, as our clouds are, by evaporation through the sun's heat, because no change is caused in them by the diurnal rotation of the planet. When they come round his edge, they reappear at sunrise just as they passed from our view at sunset. Night and day make no difference to them. The lapse of time makes no difference to them. Particular markings may last for a day or for a generation.

Examination of the light and dark bands by means of the spectroscope has shown that the light from the dark bands has passed through a deeper layer of the atmosphere than the light from the bright bands has traversed. The reflecting surface, which we see in the dark parts, is therefore at a lower level on the planet than the level of the bright white clouds; and from the sullen red colour of these darker belts it is supposed, though by no means certain that they afford a vision of a fiery, stormy interior—a sun which is changing into a world. The general arrangement of the markings in horizontal lines is believed to be due to winds set up by the velocity of the planet's rotation on his axis; and the violence of these winds may be judged from the fact that one belt may be seen sliding past that which is next to it at a rate of more than four hundred miles an hour.

One of Jupiter's markings has received great attention, and has thrown much light on his structure. In shape very much like an airship, situated horizontally in a band of bright clouds, the area known as the great red spot was first observed in 1878, when it was of a faint rose colour, and was about thirty thousand miles long, with a breadth of about seven thousand miles. Within a year it had grown enormously in size and tint, stretching across about a third of the planet's disc, and having a bright, almost vermilion colour. Four years after its first appearance it began to fade, and in subsequent years changed into a faintly coloured ring, grew again in strength of colour and definition, and has undergone many variations until the present day. The great red spot is passing away, and has never regained anything like the development which it had in 1880.

Its character has provoked endless speculation. In 1891 it was slowly pursued for several months by a small dark spot, which ultimately overtook it, and was then shattered. The great red spot was probably volcanic in nature.



SKETCHES OF JUPITER AND HIS BELTS ON AUGUST 7, 1903, AND APRIL 10, 1906.

FIVE HUMAN SPECKS ON A GLACIER

A PARTY OF FIVE TRAVELLERS CROSSING THE GEANT GLACIER FROM MONT MAUDIT

This photograph and those on pages 2949 and 2951 are by Donald Macleish

THE SOLID WATERS

The Crystallisation of Snow and Ice; the Flow of Glaciers and the Formation of Icebergs

DO THE WORLD'S ICE-RESERVES LESSEN?

ONE of the most remarkable things about water is the facility with which it changes from vapour to liquid, from liquid to solid. We have already discussed its properties as vapour and as liquid; let us now consider its behaviour as a solid.

Almost all substances, as we know, contract in bulk as they diminish in temperature, and water up to a certain point does the same. From 212° Fahrenheit to 39° Fahrenheit, water shrinks as it cools, but below that point it expands as it cools, and at 32° Fahrenheit it changes into solid crystals, with a further increase of 8 per cent in its bulk. If a pail filled to the brim with water weighs 10 pounds, the same pail filled to its brim with ice will weigh only 9·16 pounds. Since the water expands as it freezes, and since ice, bulk for bulk, is lighter than water, it follows that ice is formed first on the surface of water, and that ice floats in water. Even a mountainous iceberg will float, and about one-ninth of its bulk will be above water.

The importance of this we have already mentioned. Did water not expand but contract on cooling, did ice not float, then ice would be formed in the first place on the bottom of water. Accordingly, since water is a non-conductor, and since warm water does not sink, the heat of the summer sun would not reach the ice in the depth. Winter after winter would safely add layer on layer of ice, and eventually all the water in the world would be solid ice. The climatic and biological results of this are evident, and it is plain that the anomalous behaviour of water in expanding before and during freezing is of great advantage to the world as a habitation of living things.

At freezing-point, as we have said, water becomes converted into solid crystals, and these crystals, according to circumstances, may form ice or snow. The crystallisation of water on passing from the fluid to the solid state is no unique and exceptional phenomenon; indeed, many substances are most commonly found in a crystallised state. Well known are crystals of sugar, and salt, and sulphur, and alum. The size of any crystal is of no importance; the same substance may exhibit microscopic and massive crystals. Rock crystals, for instance, are found so small that they can be seen only through a microscope, and so large that they may weigh over a hundredweight. And any minute crystal will grow indefinitely in size by a deposition of more substance on its exterior. The important and distinguishing feature of crystals is not their size but their shape, and especially the inclination which one facet bears to another.

The crystals of snow are known to everyone. Who has not caught snow on his sleeve to examine the delicate rays of the crystal against a dark background? On examination it will be found that there are numerous varieties of snow crystals, yet each is regular and symmetrical, and each has six rays or angles, neither more nor less. W. A. Bentley, of Jericho, Vermont, United States, has photographed more than a thousand different crystalline forms of snowflakes.

Ice, like snow, is crystalline in structure; it is made up of crystals interlocked and interlaced. We cannot see the individual crystals in the solid ice, but if a block of ice be melted with a burning-glass it will be found that the melted crystals leave little spaces shaped like little flowers, each with six petals. In the beautiful ferny patterns traced by the frost on our window-panes it is easy to demonstrate the crystals. Even hail can be shown to consist of crystals.

The part played in the economy of Nature by solid water is a very important one. In

many parts of the world snow and ice are perpetual, and occur in such large amounts that they may quite legitimately be considered as crystalline rocks. In the Arctic region there is constant snow and ice, and even in tropical and sub-tropical countries, at a certain height above sea-level, snow and ice last the whole year round.

The level above which snow persists, the so-called snow-line, varies with the latitude and with other circumstances. On the north side of the Himalayas the snow-line is about 16,600 feet high; in the Andes of Peru it is about 15,500 feet high; in the Alps, about 8500 feet high; and in the northern Norwegian mountains, about 3000 feet high.

What Should We See on a Mountain Fifty Thousand Feet High?

But the snow-line varies from place to place on the same mountain range, and from year to year on the same peak. Probably if a mountain rose to 50,000 feet or so, it would have little or no snow on its summit, since all the moisture of the atmosphere would be condensed before it had risen so high. In the Alps, indeed, the greater bulk of the snow falls at an altitude of between 6000 and 9000 feet. At the Hospice of Grimsel, which is situated at a height of 6048 feet, $57\frac{1}{2}$ feet of snow, equivalent to 5 feet of water, have been recorded during six winter months. At the St. Bernard Hospice, 8110 feet high, the annual depth of snow varied during twelve years from $11\frac{1}{2}$ to $44\frac{1}{2}$ feet. At some places 6 or 7 feet of snow have fallen in a single night. On the average, we may say that every year about 30 feet of snow falls on the high Alpine peaks.

Thirty feet of snow would in a thousand years grow to thirty thousand feet, if the snow remained and accumulated from year to year. But it does not accumulate; it is melted and evaporated by the sun, and it slides down the mountain-sides as avalanches and glaciers.

The Ways in which the Winter Snows Disappear from Mountains

Rain and mist and wind also serve to dissipate it in various ways. In one day a hot sun or a Föhn wind can melt over two feet of snow, and a hurricane can remove thousands of cubic feet of snow. It must be noticed that snow can be completely removed by evaporation without any appearance of actual thaw. All those who ski and toboggan in the High Alps are well acquainted with this slow, steady evaporation of the snow.

The masses of snow which slide suddenly down mountain slopes are known as avalanches. Avalanches are of two kinds—"dust" avalanches, consisting of finely powered loose snow; and "ground" avalanches, consisting of masses of more coherent snow. It is difficult to say which is the more dangerous. Both gather volume and momentum as they descend, and may finally acquire such pace and impetus as to raze away villages, break away rocks, and uproot trees merely by the blast of compressed air which precedes them. Whole forests may be destroyed, whole villages swept away. An avalanche from the Pyrenees in 1846 levelled more than 15,000 pine-trees.

Were it not for woods on the slopes of mountains, avalanches would work still more havoc, and many plantations are specially planted for purposes of defence. So important as natural defences are the trees that at one time any man found guilty of destroying a tree in the valley of Andermatt was put to death; and it was popularly believed that drops of blood oozed from any branch intentionally broken, a superstition alluded to by Schiller in his "Wilhelm Tell" when he makes Tell's son. Walter, ask his father: "Father, is it true that the trees there on the mountain bleed if one hacks them with an axe?"

The Slow, Grinding Flow of Glaciers Down the Clefts in High Mountains

In places subject to avalanches, man, besides planting trees, has usually erected walls and basket-works. But all snow that slides down a mountain does not slide suddenly and violently as an avalanche. More commonly it moves slowly downhill, becoming more and more compressed as it descends. At first the snow consists of loose, frozen granules, then the granules are compressed into a compact mass known in Switzerland as *Névé* or *Firn*, and eventually the mass is converted into blue, compact glacier ice. The change of snow into ice is mainly a matter of compression—a change of much the same nature as the change of the snow on our heels into lumps of ice.

Though the snow in the course of its descent is converted into glacier ice, the ice is not stagnant and stationary; the whole glacier flows downwards like a river. If a row of stakes be planted in a line across a glacier, it will be found that the line of stakes will slowly be carried along downhill. It will be found, too, that the central stakes will move more quickly than the lateral ones, showing that, just as in a river,

THE SUPREME TERROR OF THE MOUNTAINS

AN AVALANCHE, BRINGING AT ONCE DEATH AND BURIAL TO THE INHABITANTS OF AN ALPINE VALLEY

the flow of a glacier is quickest in its centre. Different glaciers flow at different rates, depending on the slope of their beds and the pressure of the mass above and behind them. In 1827 a hut was built on the Unteraar Glacier and its position marked; in 1841 it was found to have moved 1561 yards down the valley, or at the average rate of 112 yards a year. The Finsteraar and Lauteraar Glaciers, tributaries of the Unteraar Glacier, were found to have a central flow of about 80 yards a year. The Mer de Glace of Chamonix moves much more rapidly. At the base of the Montanvert its rate is 822 feet annually, and its mean daily rate in summer and autumn is from twenty to twenty-seven inches centrally, and thirteen to nineteen and a half inches laterally. Faster still flow the glaciers from Greenland's icy mountains. A glacier at Jakobshavn Fiord was found during the summer to advance centrally at the rate of 65½ feet a day, and a glacier flowing into the sea at the bay of Angpadlaptok was found to flow no less than 100 feet in 24 hours.

On several occasions the rate of flow of glaciers has been demonstrated in dramatic fashion by the recovery of the bodies of men who have fallen into crevices in a glacier. In 1820 three guides fell into a crevasse in the Glacier des Bossons. In 1861, 1863, and 1865 the glacier yielded up their bodies, and it was found that in the forty years or so during which the remains had been in the glacier they had travelled about three miles and three-quarters, or about 160 to 170 yards each year. In 1860 an Austrian glacier gave up a corpse clad in a garment centuries old. It must be understood, however, that no glacier flows at the same rate from top to bottom, but that its rate of flow varies like the rate of flow of a river, and for the same reasons.

It is rather a remarkable thing that a mass of hard blue crystalline ice should actually flow like a river, and the nature of the flow is not yet fully understood. It is probable that ice is really a plastic substance, and that under tremendous pressure it flows as resin or pitch might, accommodating itself to the irregularities and inequalities of its bed. This so-called "viscous" theory is less difficult to believe when we consider that glacier ice is really composed of grains of ice from the size of a pea to the size of a melon.

ICE-FLOWERS ON ST. MORITZ LAKE, FORMED BY THE THAWING AND REFREEZING OF ICE

The movement of glaciers is also sometimes explained by the fact that ice melts under pressure, to freeze again when the pressure relaxes. According to this theory ice is successively freezing and melting, fracturing and mending. An interesting and simple experiment is often used to

illustrate the melting of ice under pressure, and its regelation when the pressure is removed. A heavy weight is slung over a block of ice by a loop of wire. The pressure of the wire melts the ice under it, and the wire cuts through the ice, but as the wire has cut down the ice the pressure it exerted is removed above it, and so the melted ice freezes again; and when the wire has cut right through the block of ice, the block of ice is found intact.

It is quite possible that both viscosity and regelation play a part in the movement of glaciers. Plastic and viscous though a glacier probably be, it never preserves entire continuity. Always stretching obliquely from the margin towards the centre of the stream, these are the fissures known as crevasses. At first the fissures point up-stream, making an angle of 45 degrees with the bank, but the movement of the glacier soon disturbs the original direction of the fissure, and may eventually produce an irregular network of crevasses. The fissures, moreover, are not permanent; they are usually soon sealed up again, though a few may widen and persist as great, yawning chasms, which may be hundreds of feet deep. The intersection of glaciers by crevasses sometimes leads to the formation of fantastic blocks and columns of ice which may resemble animals, or spires, or turrets. The tower-shaped structures of ice are known as *séracs*. In winter the crevasses are filled up with snow; and when the summer comes part of the snow remains, forming bridges across the fissures, which are often found useful by mountaineers, but which are not always safe, and may give way and precipitate the climber into the abyss.

In every country with snow-mountains, glaciers abound. In Switzerland there are no less than 2000, averaging from three to five miles in length. The great Aletsch Glacier is over a mile broad, and nearly ten miles long, and it has been calculated that there is enough ice in the Görner Glacier to make three cities as large as London. In Scandinavia glaciers are equally plentiful, and in the Himalayas and Andes there are many of colossal size. In Alaska there is the mighty glacier known as Muir's Glacier, which, with many other glaciers, flows into Glacier Bay. This glacier, where it issues from the mountains, is more than two miles wide. "Nine large and seventeen smaller branches unite to form the main ice stream, which, to the extent of a current of 5000 feet wide and 700

TRAVELLERS ON THE BOSSONS ICE-FALL

feet deep, enters the sea during the month of August at the rate of 70 feet a day in the centre, and 10 feet in the margin."

A glacier usually ends gradually tapering away as it descends, and from its termination gushes a stream formed partly by the melting of the glacier itself, and partly by streamlets which have poured on to the glacier from the hills, and have tumbled down its crevasses. The thawing of the glacier limits its downward career, and during the summer, indeed, it retrogresses and thins out. In Switzerland, the daily average summer retrogression is 3·62 inches, and the daily summer subsidence 1·63 inches. In the winter the glacier lengthens and thickens again.

Are Glaciers Increasing or Diminishing, or Do They Fluctuate Between Lesser and Greater?

At this point the question naturally presents itself—are modern glaciers advancing or retreating, increasing or diminishing? No certain answer can be given to this question. In most cases there has been an alternate advance and retreat, increase and diminution. For instance, in Switzerland, where they have been for long under observation, they retreated during the middle decades of last century, advanced again during the last decades, and now seem to be retreating again.

Between 1854 and 1869 the Glacier des Bossons receded 332 mètres, the Glacier of Bois 188 metres, the Glacier of Argentière 181 mètres, and the Glacier of Tour 520 mètres. Between 1871 and 1875 every known Alpine glacier receded. In 1875 a pretty general advance began, and during the last few years of last century the Glacier des Bossons advanced at a rate of over 160 feet a year. In 1899 the advance began to cease, and at present all over the globe, with few exceptions, glaciers are receding.

The Enormous Size of Polar Glaciers and Barriers

In certain respects, the Polar glaciers form a class by themselves, in that they flow into the sea, and break up into icebergs. Some of the Polar glaciers are of huge size. The Humboldt Glacier, in North Greenland, has a frontage of 66 miles—a frontage, that is to say, which would more than stretch from London to Brighton. The Dove Glacier in the same region is about as large, while the Eisblink pushes a tongue of ice 13 miles long into the sea. The whole of the Antarctic continent, a continent as large as Europe and Australia combined, may be considered a glacier or a congregation of glaciers, for it is covered with the accumulated snows of centuries which have been turned into ice by pressure; and the ice by its own weight is slowly and constantly slipping into the sea. The great Ross Barrier, south of New Zealand, shows the character and constitution of the continent. This barrier, discovered by Ross in 1840, is a great white cliff of ice, sometimes reaching 100 feet in height, which stretches east and west for a distance of 300 miles. Though not resembling a typical tongued glacier, this great wall of ice is in fact and act a glacier, since it is constantly flowing onward, impelled by the weight of ice behind it. One great feeder of this barrier glacier is an inland glacier known as the Beardmore Glacier, which is no less than 360 nautical miles from the sea.

When the ice of a glacier reaches the sea it usually creeps at first along the sea bottom; but after a time its superior buoyancy forces it upwards, and under the strain the glacier fractures, and a great mass of ice is broken off, and floats in the sea as an iceberg.

An Iceberg Large Enough to Block Up the Whole English Channel

Icebergs are stupendous. Those broken off from the Jacobshaven ice-field in North Greenland may rise over 600 feet above the sea, which means that the total height of the iceberg from base to summit is greater than the height of Ben Nevis. Hayes measured an iceberg 315 feet high above the water, and more than three quarters of a mile long, and calculated that it weighed 2,000,000 tons. Ross and Parry described one 153 feet high and 2½ miles broad, whose entire mass might be about 1500 million tons. The Antarctic icebergs are not so high as the Arctic ones, but some are of enormous extent. Dr. Bruce, the leader of an Antarctic expedition in 1902-4, declares that he saw many icebergs at least a mile long, and that on one occasion he measured a berg 12 miles long and that "on another occasion the 'Balæna' steamed at the rate of five knots for six hours along the face of a berg, which made the length of it fully 30 miles." Imagine an iceberg 30 miles long! It would be long enough to reach from Dover to Calais, and block up the whole English Channel!

Such enormous masses of ice may float for great distances before they melt. Icebergs from Greenland may get as far south as the coast of Spain, and icebergs

ICY ABYSSES OF THE MONT BLANC RANGE

EXAMINING A CREVASSE EIGHT HUNDRED FEET DEEP ON THE GLACIER DU GÉANT

from the Antarctic glaciers may get as far north as the Cape of Good Hope. The number of icebergs that cruise about the sea must be very great. In Baffin's Bay, Dr. Kane once counted a pack of 280 bergs. Dr. Bruce counted sixty from the deck of the "Balæna." During the winter of 1903 a constant procession of icebergs drifted past the South Orkneys for eight months.

Even in the track of the great liners that cross between Europe and New York icebergs in great numbers may be seen during certain months of the year, and many a good ship has been ripped and wrecked by the mighty ice crags. Southward of Newfoundland the floor of the ocean must be littered with ships and dead men's bones, for here, in the mists that hang around these regions, many ships have gone to their doom. In this region occurred the greatest tragedy that has ever occurred at sea. In the first weeks of April, 1912, the "Titanic," the most magnificent and colossal vessel ever built, started on her maiden voyage to New York. Terrace above terrace, she rose from the sea like a floating palace. Man's highest science and art had gone to her construction. Her engines represented enormous power, and yet were as delicately finished as a watch. She had swimming-baths, and gymnasiums, and tennis-courts, and restaurants, and was the last word in luxury and refinement. She was made to be stronger than the waves and hurricanes, was honeycombed with water-tight compartments so as to be practically unsinkable. On board were over two thousand souls—immigrants going with large hopes to the new land, famous journalists such as William Stead, famous millionaires such as Colonel Astor, famous artists such as Frank Millet. Proudly the great ship bore her freight of human lives across the Atlantic. But she was never to reach her destination. It was iceberg season; the boats preceding her had passed icebergs and ice-fields unusually big and formidable, and had sent her warning. Yet, despite the warning, the great steel palace ran into a great black berg. So colossal was the boat, so elaborate the measures taken to render her unsinkable, that even after the collision those on board felt little fear. But the sharp tusk of the ice had ripped the great ship open, and she gradually filled and sank into the fathomless depths of the ocean. What neither wind nor wave could destroy an iceberg shattered.

HOW ICEBERGS BREAK AWAY FROM A GREENLAND GLACIER

Dangerous and formidable as they are to the mariner, icebergs have a beauty, a grandeur, and a solemnity that appeal to the beholder. "Their stupendous size," says Dr. Bruce, "their exquisite architectural composition, more magnificent than the temples and pyramids of Egypt, more overpowering in solemnity than the Sphinx, make the most thoughtless think for a moment of the Power that controls the forces of Nature." And on one occasion, when the "Balæna" sailed through a crowd of bergs—"At one time we passed through a regular street, lined on each side with towering bergs, each a temple in itself, now Doric, now Egyptian, each perfectly carved and shaped, each purer and whiter than the other, glittering in the sun, pearl-grey in the shade, and rich blue in the clefts and caves which pierced their sides. This street or avenue was several miles long; indeed, some individual bergs were fully half a mile in length. Side avenues opened into this main avenue."

Bergs are more dangerous to mariners when they are massive and unmelted, but even when they are melted down to fractions of their original selves they remain perils of the deep. The final remains of icebergs are known as "growlers" and "bergy bits." They are particularly hard ice, and many is the good ship they have ripped up. Bergs and bergy bits are also indirectly dangerous, in that they condense moisture and cause sea-fogs.

Besides the ice formed from snow by compression, there is, of course, ice formed directly from water by the action of frost. In some latitudes the rivers and lakes and inland seas freeze in winter and thaw in summer; in other latitudes there is frozen water all the year round. Examples of the first sort are seen in the Siberian rivers, in the Baltic Sea, and the St. Lawrence with its lakes. Examples of the latter sort are seen in the Arctic and Antarctic regions.

In Canada the ice on the lakes and rivers is one and a half to two and a half feet thick. When river ice breaks up, the ice rends and tears the banks of the river, and wears down any islands in the centre of the stream. Sometimes a river gets dammed up with heaps of broken ice; and when eventually the swollen river bursts the dam it may work great destruction.

As a rule, ice forms on the surface of rivers, but sometimes it forms on the bottom. The rationale of this formation is supposed to be that the cold water of the surface is mixed by the currents into the general body of the water, and so the river is uniformly cooled down to freezing-point. That being so, the stiller bottom water in contact with cold stones freezes first. This ground ice, which is sometimes known as anchor-ice, often floats to the surface, and lifts with it stones, gravel, sand, and other materials to which it may be attached.

The ice formed on the surface of the sea is of special interest. Not till the temperature falls to 28° Fahrenheit or thereabouts does the sea freeze, and when it does freeze it forms an ice differing in many ways from land ice. If the surface of the open sea be observed when the temperature falls to 29° Fahrenheit and lower, it will be found to be overspread with delicate spicules; and if the temperature keeps low these spicules will increase till they form a layer two or three inches deep. A layer of fresh-water ice of two or three inches thickness is strong enough to skate upon, but a layer of sea ice of the same thickness is soft like glue, and will not bear a child; in fact, a seal can easily knock its nose through, and an ordinary ship can plough through it. If snow falls upon such a layer of ice spicules, the ice spicules and snow crystals lock together, and the depth of the layer is increased; and very often the earliest layer of ice on Polar seas is of this mixed nature. Newly-formed ice of this nature is known as "bay ice," since ice is formed first in sheltered bays, or "black ice," because it is black and translucent.

ICEBERGS FLOATING PAST NEWFOUNDLAND, SOUTHWARD BOUND

Naturally such ice is frail and fragile; and soon, under the heaving of the tides and the threshing of the winds, it is broken into hexagonal fragments a few inches or a few feet in diameter. These hexagonal discs again get crushed and knocked about, and thicken with the frost, and become what is known as "pancake ice." The pancakes, again, get frozen together into a rough, tessellated pavement of ice, and this pavement, in turn, is broken into bigger hexagons, which again are congealed

together. Finally a pancake patchwork of thick white ice is formed strong enough to resist the efforts of the sea to break it. If the sheet of ice is large it is called "floe ice"; if it extends continuously farther than the eye can see it is known as "field ice." But a distinction must here be made. This is floe ice or field ice of the first season—débutante ice, so to say. But floe ice and field ice are not always formed *de novo* out of sea water; they may be formed out of fragments of the former winter's new ice when it breaks up in the summer. In this case, when the floe ice or field ice is not born of bay ice, but built up out of fragments of former floe ice or field ice, it is much rougher and stronger.

When fields and floes break up they first fracture into small floes, but these again split up into fragments mostly a few feet in diameter. In this condition the ice is known as "pack ice." Pack ice drifts before the wind in mighty streams with irresistible power until the separate pieces are again welded by frost into fields or floes. Often the pieces are hurled together in heaps; and when they freeze together we get what is known as "hummocky ice." Round the margins of pack ice there is usually a collection of much smaller fragments, known as "brash ice."

ICE-FLOES OFF THE COAST OF LABRADOR

When the sea-water freezes it leaves almost all its salt contents behind; and though there may be some brine on the top of sea ice, the ice itself is almost pure water, and is quite good for drinking and washing purposes. Almost all Antarctic ice has a yellowish-brown layer sandwiched in it just about sea-level. Pack ice, floe ice, berg ice—all show this coloured layer. In Arctic ice the same layer occurs, but it is more superficial. When this coloured layer is examined it is found to consist of myriads of diatoms, which make the ice their home. Since the layer spreads for hundreds and hundreds of miles, it represents a tremendous population of diatoms. Curiously enough, as Dr. Bruce points out, they serve as protective colouring for the Polar bears, which in winter are a light yellowish colour, resembling the colour of this layer, and hardly even at a moderate distance to be distinguished from it.

In some parts of the Polar regions, especially in Spitzbergen and Novaya Zemlya, acres of snow and ice are coloured red. This is due to the blood-red microscopic alga known as *Sphærella nivalis*.

It is remarkable that, even in ice, life should survive. Dr. Bruce melted pieces of wet soil and moss that had been subjected to a temperature of -45° Fahrenheit, and as soon as they were melted myriads of minute creatures sprang into activity, and "a small nematode worm, that had evidently been on the point of laying its eggs when overtaken by the frost months previously, began to lay them as soon as it had melted out, and continued its life as if nothing had happened during this long period of sleep."

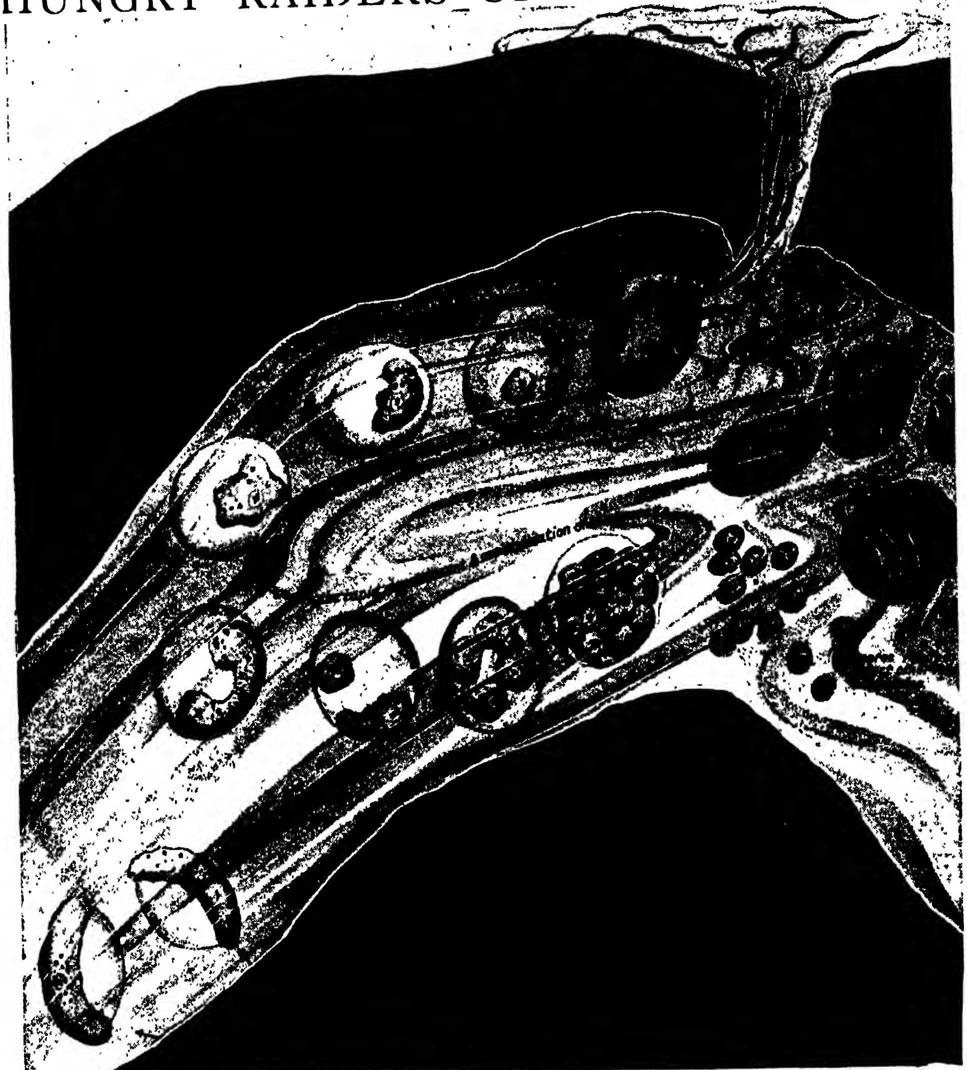
Hail may be briefly mentioned. It consists of little particles, usually about the size of small shot, which fall from the upper atmosphere. Hail falls in summer rather than in winter, and by day rather than by night, and is difficult to explain. It is probably formed of raindrops which have been carried up into the colder higher regions of the atmosphere, and frozen there. Though usually about the size of small shot, hail may occur in pieces several inches in diameter, and a hailstorm in such a case may do great damage to fields and flocks. In August, 1911, such a hailstorm occurred in the Pyrenees, which was graphically described by a correspondent in the "Times."

"Presently marble-sized hail fell and lightning blazed, driving my wife from the dangerous shelter of the umbrella. We then decided to watch from the door of the tent, which opened upon the river. Suddenly the whole land was bombarded by great hailstones as large as lawn-tennis balls. They fell with a deafening roar on the canvas of the tent, leapt about round the door, and bounced in at the entrance. It seemed only the matter of a few seconds for us to be battered into the earth, tent and all. We were, too, in the very heart of the thunderstorm, for lightning and crashing thunder came at one and the same instant. Outside, past the open tent-door, the river roared in a terrific brown torrent, splashed far over its banks and torn by the volleying hailstones. We cowered in the tent under the big umbrella, and, wrapped round with the thickest clothes we could lay hands upon, listened in mute amazement. The battering on the tent went on unremittingly. The indiarubber bath in front of us, with its sides beaten down in places, was half full of things like white cricket-balls. A stream of water began to run through the centre of the tent, showing that the surrounding trench had overflowed. The minutes went by slowly. It seemed all the time past reason that our tent could withstand the onslaught a moment longer. As a last resource we blew up our air-cushions to put them on our heads when the canvas should be shattered. . . . 'La tormenta,' as the storm was called, visited many Pyrenean valleys, and wrought much destruction. Seventy sheep owned in Torla were killed on the heights immediately above us. Many more died afterwards, and it was said that the sight of their battered corpses and of the broken-limbed survivors was piteous to behold. Above the village of El Plan thirty-five cows and some mules were killed, and were washed down in the River Cinca; and here, too, was the only case I heard of of human loss of life, the body of a child who had been wandering about in the mountains being brought down by the same stream."

FERRY-BOATS PLOUGHING THEIR WAY THROUGH THE ICE-STREWN WATERS OF LAKE MICHIGAN

The devastation caused by hail may be very extensive, for it only falls in its more destructive forms in the summer, when the crops have reached a stage in which they are easily damaged. Often hailstorms are accompanied by violent winds, which add to their dangers. It has been calculated that the destruction wrought by a single storm, of unusual dimensions and persistence, has amounted to a million pounds' worth; and in the course of such a storm stones weighing as much as three pounds have been precipitated from the sky.

HUNGRY RAIDERS OF HUMAN BLOOD



THE DEVELOPMENT AND FISSION OF THE MALARIA PARASITE IN HUMAN BLOOD

THE FERTILISATION AND DEVELOPMENT OF MALARIA PARASITES WITHIN THE MOSQUITO

The upper picture shows the form in which the malaria parasites, present in large numbers in the saliva of the mosquito, enter a minute capillary of the blood through the wound made by the bite. One can be seen penetrating a red blood corpuscle, and several successive stages of the parasite's development and multiplication by fission are shown, the free spores thus formed being capable of infecting fresh corpuscles. The sexual types of the organism, shown in the bottom left-hand corner, will pass into the mosquito through the human blood, upon which the mosquito feeds. These sexual varieties go through the series shown in the lower picture in the body of the mosquito, finally developing into the spore form which infects he human species through the wound, as shown above.

THE UNIVERSAL PARASITE

The New World of Internal Life, Hitherto Invisible, Revealed by the Microscope

THE PLACE OF PARASITES IN DISEASE

Strictly speaking, it is not so easy to define parasitism, for any definition will be almost certain unintentionally to include, for instance, man as a parasite upon the cow, whose milk we consume. All forms of life are so interdependent that, from one point of view, anything specially to be called parasitism can scarcely be distinguished at all. We must also exclude symbiosis, as illustrated in the lichen, where two forms of life enter into a mutually advantageous partnership. We must exclude saprophytism, the case of those many vegetable organisms which live upon *dead* organic matter or upon organic products. In the strict definition, man would be saprophytic rather than parasitic upon the cow, for milk is not itself alive. We must confine parasitism to the cases where one living creature lives upon the living organism of another creature, which is called its host.

It might almost be convenient to introduce the idea of injury to the host, but that would not do. No doubt the incidental injury to the host is very important, and, indeed, matters everything to ourselves, who are liable to be the hosts of so many unwelcome and even deadly guests. There are plenty of cases of parasitism where it is impossible to say that the host suffers any injury, but the parasite is definitely a parasite, none the less. Bacteriologists have identified some thirty different forms of bacteria among what they quaintly call the "flora" of the mouth, but most of these are entirely innocent, no doubt. Similarly, the "flora" of the bowel includes many forms which are harmless, and may even be beneficial. Therefore, the idea that the parasite necessarily injures its host must be abandoned.

It may fairly be said that parasitism is a universal fact of the living world. This was long ago stated in the familiar lines—

Great fleas have little fleas upon their backs to
bite 'em,
And little fleas have lesser fleas, and so *ad infinitum.*

We shall soon see that this is far truer than anyone could guess until the perfection of modern microscopy. But these lines may serve to remind us that parasitism, in its more familiar form, means the presence of smaller organisms upon the exterior of a larger one, as in the case of the flea. We now know, however, that parasites may just as well thrive inside the body of their host. The convenient distinction may thus be made between ecto-parasites and endo-parasites, which live respectively without and within the body of their host.

Everyone is familiar nowadays with the bacteria, many of which are parasitic. Their dimensions may be very small, as in the case of many round forms, called cocci, which may have a diameter of as little as one *micron*, which is the twenty-five-thousandth part of an inch. A millimètre is about one-twenty-fifth of an inch; but so minute are the dimensions of these creatures that we require to use a new unit, called the micron, which is the thousandth part of a millimètre.

It may very naturally be supposed that such dimensions would be the very limit of living forms, and until lately it was so supposed. But recently the lines of the versifier have been justified, and the limits of parasitism have been extended almost "*ad infinitum.*" We have good reason to believe that still more minute organisms, the dimensions of which can only be expressed in millionths of an inch, are to be found parasitic upon the bacteria.

When we study the limits of microscopic vision, which depend upon the wave-length of light, so that, even by oblique illumination

with light having a wave-length of, say, one-forty-thousandth of an inch, we can only see objects of at least half that dimension, it will be realised that these minute organisms are ultra-microscopic. Their existence may be demonstrable by their effects, and their properties may be definable, but, except in indirect and partial fashion, the eye of man cannot hope ever to see them.

Parasites So Small that the Microscope Cannot Detect Them

This discovery of ultra-microscopic forms of life is so important that we must briefly refer to it further before we proceed with the subject of which they are only the most extreme illustration. In due course we shall learn that there are several diseases in which no one can doubt that a parasite is involved, but no such parasite can be found. Infectious material may be searched by every modern refinement of technique and staining, but nothing can be seen in it. Students have long suspected the reason to be that the parasite in these cases was ultra-microscopic, a suspicion which we must now accept as verified. It raises many new problems, for evidently we are deprived of our right hand when the microscope itself fails us.

It is quite likely that the unknown parasite which produces foot-and-mouth disease in cattle belongs to this category of the ultra-microscopic. We may just remind ourselves, however, that it is only in recent years that the bacteriologists have been at all justified in the assumption that what they cannot see is invisible, and in some instances, no doubt, they will be able to disprove their own suspicion.

So much depends on technique. If we follow the proper procedure we can always readily find the tubercle bacillus, when it is present, but that procedure involves treating the bacillus with something which enables it to hold a certain dye or stain, and then applying the stain in question. Until we go through this procedure in just the right way, we may look for years and find nothing, as Koch did in this very case before he succeeded.

The Progress of the Discovery of Organisms Too Small for Sight

Another instance is furnished by the parasite of syphilis, which was discovered some half-dozen years ago, and which is really quite large, so far as its long dimension is concerned, but it is so exceedingly slender and transparent that it escaped all search for decades. Nevertheless, if we keep these warning instances in mind, and remember how thoroughly bacteriologists have taken them to heart, we must still agree that really ultra-microscopic organisms do exist.

Those hitherto "discovered," if that word may be used, are parasitic; but it remains to be seen whether similar organisms may not exist which are non-parasitic, and which perhaps lay the chemical foundations for all higher forms of life. However that may be, these recent discoveries in parasitism have required us to modify our ideas on the very interesting question—how small may a living organism be? It is now clear that life may be manifested in individual units which are so small that the number of actual molecules in them begins to be enumerable. And as our knowledge in this direction extends, the physico-chemical conceptions of life which satisfied most men of science in the nineteenth century seem to become less tenable than ever. But this is a field of inquiry so novel that we can as yet do no more than recognise its existence.

The Parasite's Aim—to Live on Ready-Made Food

Having learnt how general a fact parasitism is, extending from such large creatures as, say, the tapeworm, down to forms which no microscope can reveal, we should ask ourselves why this should be so. The answer is that parasitism solves so easily the chemical problems which face every living creature. In order to live, protoplasm requires a constant supply of the particular elements and certain of the compounds of which it is made.

These quite indispensable materials may, of course, be laboriously and honestly gathered, one by one, from their various natural sources. The process will tend to be a slow one, and at any time the sources may not be available. Obviously, there is a short cut, and that is to avail oneself of the collection and elaboration which some other living creature has already made. This convenient arrangement, with no disadvantages at all, we see in the case of many external parasites, such as the blood-sucking insects, which have lately become of such enormous importance to our understanding of disease, in consequence of the fact that they themselves have parasites, which they hand on to the creature they bite. The flea or tsetse-fly or mosquito lives conveniently by helping itself to a ready-made fluid, rich in nourishment, which the life of another creature has elaborated for its own purposes. Other parasites do better still, as in the

case of that admirable product of natural selection, the tapeworm. This creature, which we may take as typical of many, benefits by its parasitism to the greatest possible extent. The body of its host provides it with warmth and shelter. It has no need of locomotion, nor of any kind of exposure. The flea or mosquito requires to digest the blood of its victim, but the tapeworm does much better. It takes up its abode in the bowel, just where the food reaches its fully-digested form, and it thus has available a plentiful supply of predigested food, which comes to it, and demands no effort whatever but that of receiving it.

A universal rule of parasitism is that the degeneracy of the parasite is in proportion to its dependence. Thus, in physical terms, at any rate, there is little degeneracy to be observed in the mosquito, which has to fly, to bite, to digest. But the tapeworm has to do practically nothing, and so all its organs degenerate, except those of reproduction. It loses its means of locomotion, its senses, its power of digestion, and so forth; these are not called for; it has chosen an easier way of life, and they disappear accordingly. This can scarcely be called a case of the struggle for existence. The tapeworm produces no poisons, and the body makes no attack upon it.

Disease Often a Struggle Between Poisonous Parasites and Substances that Defend the Body

But with yet other parasites the case is very different. These are typified by the parasite of malaria, which is an animal, and that of consumption, which is a plant. Here the struggle for existence is genuinely illustrated. Originally, of course, we are to imagine no animosity on the part of the parasite towards its host. It is merely trying to avail itself of an abundant source of nourishment. In the course of doing so, however, it produces substances, commonly called toxins or poisons, which happen to be noxious to its host. The host therefore tries to protect itself, by producing substances which will kill the parasite; and thus a struggle for life begins. It is this struggle which we see illustrated only too often, and which we call disease. The details vary widely in different cases, but this is the essence of nearly all of them.

Parasitism being the general fact of the living world that it is, we must be prepared to find that animals and vegetables alike have parasites, and that these may themselves be animal or vegetable. At one moment you may be spraying your throat with an antiseptic, and at the next your rose-bushes; and in each case your object is to kill parasites. In the case of mankind the parasites first known were, of course, the biting insects. Then we discovered other animal forms, living within the bowel, though some may live, during part of their life-cycle, in other organs, such as the muscles and the liver. Much later, thanks to the chemical study of fermentation and the improvement of the microscope, we found a variety of vegetable parasites, far commoner and more important than any known animal parasite, internal or external.

Some Animal Parasites which, Like Vegetable Parasites, are Dangerous to the Body

While the greater number of diseases could be accredited to these minute plants, only one case was known where a minute animal played a similar part. This was the case of the parasite of malaria, discovered by a French army surgeon, now Professor Laveran, some thirty years ago.

Within recent years, however, the number of these minute animal parasites has been greatly augmented. Syphilis, for instance, is due to one, so that they can already claim two of the most important of all diseases. A terrible form of dysentery is also due to an animal parasite, of the class of amœbæ, known as the *amœba dysenteriæ*. Still later, a new genus of animals has had to be recognised as parasites, causing the various forms of disease called trypanosomiasis, after the parasite, called the trypanosoma. But there are many different forms of trypanosoma, whose normal habitat is the blood of many creatures besides man, and that which causes sleeping-sickness in man is only the most important.

Parasitism a Lazy Acceptance of "Most Life at Least Trouble"

We are clearly to understand, then, that parasitism is not only a relation between an animal on the one hand and a vegetable on the other. It occurs in all possible ways; and we know no form of life, animal or vegetable, which is wholly immune from parasitism. We think of many insects as parasites, and so they are, but the insects are themselves subject to parasites, like the lamentable infections which attack bees; and even parasitic insects like the malarial mosquito are themselves the hosts of the animal parasite with which they later infect man. And in the blood of worms or fishes we find parasites in just the same way. Similarly, it may be said that almost every form of life can be persuaded to become parasitic under suitable circumstances; it

will always be glad to accept the most life at the least trouble.

Every parasitic species has taken to this mode of existence somehow. If we could trace its line far enough upwards, we should find non-parasitic ancestors at the head of it. But to this rule—that species in general can be persuaded, only too readily, into parasitism under suitable circumstances—the green plants, taken as a whole, are the honourable exception. In virtue of their chlorophyll, as we may remember, they have direct access to an endless source of energy in the form of the sunlight which pours down upon them; and under favourable conditions their growth merely becomes more luxuriant and abundant.

Green Plants which Live as Parasites at the Expense of Their Fellows

But even here there are certain striking exceptions. No green plant is parasitic upon animals. We have quite enough to fear from the vegetable world, but only from the fungi. Certain green plants are, however, more or less wholly parasitic upon other plants. The general rule is that they germinate in the ground, often with some honest roots of their own, by which they obtain the salts in the soil-water, but also with a root in the underground portion of their host. Several plants, such as the eyebright, have small green leaves of their own, so that they are only partly parasitic. Others, such as the broom rapes, have really lost all their chlorophyll, and are wholly parasitic but for the fact that they have some roots of their own. The dodder, after twining round the stem of its host, into which it sends sucker-like branches, dies at its own root, and thus ceases to have any connection with the ground. The sucker-like branches, which are modified roots, serve all its purposes at the expense of its host.

Parasite Specimens of Plant and Animal Life, Up to the Man who Sponges

The mistletoe is in part a parasite, but by no means wholly so, for it has green leaves, and therefore is able in large measure to feed itself. The ivy, though often thought of as parasitic, is not so at all, having green leaves and true roots of its own, and merely using trees, as it would use a wall, for purposes of support. Among flowering plants, perhaps the most striking and thorough-going parasite is the rafflesia, discovered by Sir Stamford Raffles in Java, nearly a century ago. It has no foliage leaves at all, and grows on the trailing stems of a vine, producing a huge flower some two or three feet across, at the top of a short root which penetrates the stem of the vine.

By far the most important animal parasites are those microscopic forms which have only lately been discovered. The number of parasitic animals decreases rapidly as we ascend in the evolutionary scale, as might be expected. The many parasitic worms have already been referred to, as also the parasitic insects. But among the vertebrates, only one family of fishes is parasitic, these being best represented by the hagfish, or borer. This fish is to be found where the cod abounds, and it lives by penetrating into the body of the cod, and feeding upon its flesh. Nominally and technically, no parasites are to be found elsewhere in the whole great scale of vertebrates; but, psychologically and actually, we all know that the universal tendency towards parasitism is exhibited in not a few members of our own species, and that the universal penalty, which is degeneracy, is always exacted of them.

Though parasitism is so widely distributed throughout living Nature, its presence does not always connote the existence of disease on the part of the host. On the contrary, just as we are the hosts of many microbic forms of life which do us no harm, so we find that parasitism elsewhere in most instances causes no injury to the host.

The Way in which Animals Accommodate Themselves to Parasites

This is what we should expect to find under long-standing conditions, where evolution has reached a kind of stable state. Obviously, a parasite which exterminated the host upon which its own existence depended would itself become extinct; and that may have often happened. It is by no means to the interest of the parasite to destroy its host, any more, indeed, than that its host shall destroy it. The best arrangement for the parasite is one of equilibrium, in which it is tolerated by the host; and that means that the host ceases to suffer, or to suffer appreciably, from the presence of the parasite.

If, now, we study the facts in some country where the conditions have long been constant, where man has neither exterminated old species nor introduced new ones, nor domesticated wild forms and introduced them to an abnormal mode of life, we find the state of balance just described. Numerous parasites will probably be found in the blood and tissues of the wild animals. These may resemble, or be even identical with, parasites which we ourselves or our domestic animals have reason to fear. But

under the natural conditions they do no harm, for a state of equilibrium has been attained. Their hosts accommodate them, but thrive in spite of them. The question arises—how has this adaptation been achieved? The answer to it is very important, for it will guide us as to the prospects of any new species, such as ourselves or our horses, which propose to settle in the district.

One view is that, by a steady process of natural selection, carried on through many generations, the host has reached a state of immunity to harm from the parasite which it harbours. Susceptible individuals have been persistently exterminated; while those which happened to vary in the direction of resistance would survive, and transmit their advantage to their offspring. In course of time there would thus be evolved an immune race, but its immunity would be by no means shared by any new-comers who had not been through the same discipline. This is one interpretation, of which the chief exponent, for many years, has been Dr. Archdall Reid. But the problem is exceedingly complicated, and other interpretations are possible. Thus, the state of balance and immunity on the part of the host may have been reached because, in the course of generations, those strains *of the parasite* which were most deadly have exterminated themselves by the destruction of their hosts, while those which were less ruthless have spared the host, and have thus survived. In other words, the evolution may have occurred in the parasitic species, and not in the host species at all.

A PARASITE ON MAN—TRICHINA SPIRALIS ENCYSTED IN MUSCULAR TISSUE

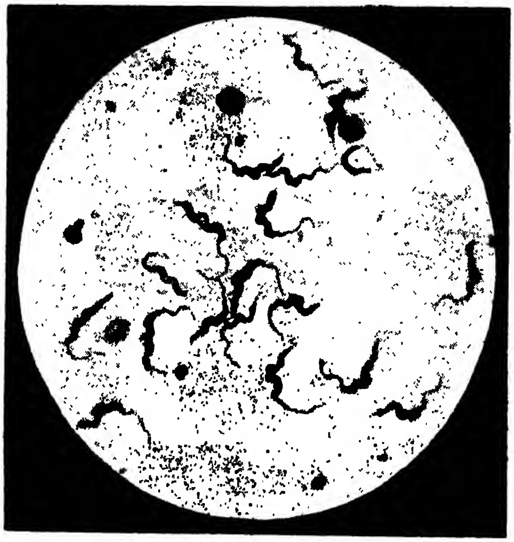
A third explanation, which may be called Lamarckian as against the former, which are Darwinian in principle, is that the individuals of the host-species have personally acquired some degree of resistance to the parasite, involving a profound and general modification of their body chemistry, and this "acquired immunity" has been transmitted to their offspring. The thorough-going Darwinians deny, *in toto*, the possibility of any such thing, on a variety of grounds which are quite arbitrarily laid down. It may be the true explanation, after all. In any case, the problems involved concern mankind in the most intimate way.

The control of the tropics, the mastery of disease, the spread of civilisation, the ultimate total numbers of the human population of the earth, and the proportions thereof contributed by the various races—all these largely depend upon the problems of parasitism. Thus, to take a familiar example, we speak, or used to speak, of a certain part of Africa as the "White Man's Grave," because of the liability of white men to fall victims to malaria there. If we examine the children of the natives in such regions we find their blood swarming with malaria parasites. They do not suffer as we do. Assuming that the parasite must remain (though in many instances the problem can be abruptly solved by the extermination of the parasite) we have to decide whether, and, if so, how, the white man can reach the immunity enjoyed by the native; and we have also to decide whether this is really an immunity worth having, or whether, in point of fact, the native race is not degenerate, the victim of racial poisoning through generations of parental malaria, as Sir Ronald Ross believes.

In cases where the parasite can be exterminated by the mind of man, a new factor in evolution, which identifies it, and destroys its breeding places, no further problem remains. But in many instances man cannot do so—at any rate, yet: and the question arises—what is he to do? Sharp controversy will now arise between the exponents of the various interpretations which we have just looked at. The pure Darwinians, strenuously teaching what Darwin repudiated, will argue that only natural selection by the parasite will produce immunity against it. In the case of tuberculosis, for instance, which we shall shortly have to

consider in detail, they say that medical science and philanthropy can only interfere with the sole means by which a race may acquire immunity to a disease—namely, by the gradual elimination of the most susceptible. They argue that in this way alone can a race be made strong; while the Lamarckians argue that in this way it will be made weak, owing to the cumulative action of the disease-poison upon successive generations. These are differences which, in fact, cannot be resolved upon paper, for it all depends upon what we begin by assuming; and they require exact observation as to what actually happens in nature.

But in any case it is true that the facts of parasitism play a very large part in evolution, and in the distribution of living forms. To take our own species as simply one among millions, evidently its geographical distribution has depended in the past, and depends at the present moment, upon the distribution of certain parasites. Where they abound, man is absent, or is found in only very small numbers. Mere physical conditions trouble him little. He penetrates everywhere, as all species try and tend to do, but the barriers which he cannot penetrate are those set up by parasites which would destroy him. Within those barriers there may exist certain small numbers of men, either degenerate or else specially adapted, and resistant within limits, but a non-adapted race cannot pass them without heavy penalties. On the other hand, members of the race within the area of parasites may be removed, and then multiply amazingly, like the negroes in the United States. What is true of man is true of many other species of animals and plants. If we examine their distribution and its limits we find that they are determined by the presence, beyond those limits, of creatures which would become parasitic upon them. Under the conditions of nature, things have mostly adjusted themselves. Perhaps a species has become resistant, in any or all of the ways we have discussed. Or else the species simply does not occur where the parasite or the potential parasite occurs.



TRYPANOSOMES TRANSMITTED TO HORSES AND CATTLE BY TSETSE FLIES

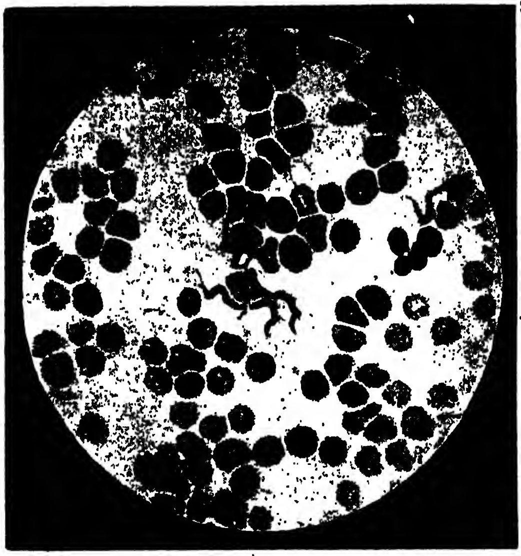
On the whole, then, the fact of parasitism does not connote any appreciable quantity of disease in a state of nature. The internal characteristics of species, host and parasite, and their distribution, are so evolved that, in general, disease exists to only a very small degree.

But this we only begin to appreciate when we observe the consequences of any interference with the existing adaptation. We modify our own conditions, as in the formation of great urban aggregations, and promptly find ourselves the victims of many parasites. We penetrate to places where our race has undergone no evolution—Darwinian, Lamarckian, or other—and again the result is disastrous. We take our horses with us to serve us, and find them the victims of an infection, transmitted by a blood-sucking fly, to which the native animals are practically immune. Just the same happens with many of the plants which we desire, and introduce into novel situations.

The work of the last few years, beginning with the labours of Sir Patrick Manson and Sir Ronald Ross, now a long time ago, has given us a general picture of parasitism which may apply to many cases hitherto obscure. First demonstrated in the case of a kind of malarial infection in birds, it is now seen to be a fair statement of a practically world-wide state of things. We have seen that the animal kingdom may be subdivided into two great parts, the invertebrates and the vertebrates. These latter culminate in the mammals, and more especially in man. At the head of the invertebrates we find a vast variety of insects. The struggle for existence, and for the possession of the world, is largely seen to resolve itself into a curious contest between certain of these insects and man himself. But it would be no contest worth

mentioning if the insects were merely parasitic upon the blood of man and no further complication existed. In that case the insects would be no more than inconveniences. Fleas are a nuisance, but they do not actually limit the distribution of the human species, or keep down its numbers; or, at any rate, fleas do not in this country. The loss of a little blood, to feed so small a creature, really does not matter.

The world-problem depends upon the fact that the parasitic insect is itself the prey of parasites. The insects which are not, such as fleas in this country, do not matter for evolution. They are merely a nuisance. But many insects matter immensely for the future distribution and quality of life upon our planet, not merely because they are parasitic upon man and other vertebrates, but because they are themselves the hosts of parasites which occupy a place very low down in the animal scale, or sometimes in the vegetable scale, as in the case of the bacillus of plague. The insects distribute, in various ways, the parasites which invade them. In some cases, as we shall see, the insect is merely a vehicle, not essential for the maintenance of the life of the parasite. Such seems to be the rat-flea in conveying the bacillus of plague from the rat to man. But in other cases the vital relations are much more complicated, for the minute parasite requires to pass a necessary part of its life-cycle in the body of the insect, and another part in the body of the mammal whom the insect bites. This parasite thus becomes the instrument with which the insect wages against man, or animals valuable to man, the fight for the possession of the world; and upon the solution of these problems, as we shall see, depends the hygiene and the destiny of the tropics.



TRYPANOSOMES OF SLEEPING SICKNESS TRANSMITTED TO THE BLOOD OF MAN BY A BITING FLY

Thus from the biological problem of parasitism in general we pass to the special problems of the conquest of disease, in so far as that depends upon parasitism. Close acquaintance with parasitic disease has taught us that it is largely a matter of chemistry—the special chemistry of the parasite and of the host, and the relations between them. Given sufficient knowledge of chemistry and of the special biology of the parasites, problems of disease thus become soluble. In surprising but unequivocal fashion they are removed from the sphere of the doctor. He may study his patients and their symptoms with infinite assiduity, but he will never be any nearer the understanding of the causes some of the results of which are all that he can detect. His experience, his stethoscope, his skilled touch, trained eye, everything characteristically medical about him, including his knowledge of drugs and of the art of prescribing—all these are set aside. The greater part of all disease is seen to be not a medical problem at all.

Medicine, which is literally the business of healing, may be allowed to rule in the actual care of the patient, but the essential problems, the solution of which will make all medicine by so much superfluous, are not medical at all. They are biological and chemical. They can be solved only by the application of biological and chemical knowledge—any number of lifetimes of clinical experience would leave us where we were in regard to them.

When we look backwards we see that our knowledge dates, on the whole, from a single man, who never held a medical degree, but was essentially and originally a chemist; but he carried his chemistry to such lengths as ere long made him the greatest doctor of all time, the father of preventive medicine, who told us that "it is in the power of man to make all parasitic diseases disappear from the earth." In due course this chemist, Louis Pasteur, became a master of a great province of biology; and as such he falls to be considered now, at the beginning of our study of the conquest of disease.

PLANTS THAT FLING THEIR FRUIT AFAR

THE PODS OF TARES CLOSED BEFORE, AND OPEN AFTER, THE DISPERSAL OF THE SEEDS

THE FRUITS OF ESCHSCHOLTZIA

FRUITS OF MARSH CRANE'S-BILL

FRUIT AND SEED DISPERSAL

The Scattering of Plants by Varied Devices—the Slinging, Catapulting, Creeping, and Hopping of Fruits

TRAVELS OF A SEED BY LAND AND SEA

In our last chapter we considered the general principles upon which the dispersal of plants over the surface of the globe was based, and outlined some of the principal methods which plants adopt in order to secure their own distribution. The subject is such an interesting one, from the point of view particularly of the special mechanisms evolved by plants in order to assist themselves in this direction, that we propose to study in a little more detail some of the most striking examples of adaptation. We have seen how plant distribution is attained sometimes by means of offshoots, runners, and long underground roots, but here we wish to note more especially adaptations for the dispersal of fruits and seeds, for in these some most beautifully impressive arrangements are to be found.

Readers of Goethe's " Travels in Italy " may remember a passage in which he describes the surprise he experienced in connection with some capsules of a plant he had brought home. These he had placed in a box, and had taken no more notice of them for some time. He relates how one night he was aroused by a distinct crackling noise, immediately followed by a sound suggesting to him a number of small bodies being thrown against the walls and the ceiling of the room. He was quite puzzled at first to account for this, but, on searching for a cause to explain the phenomenon, found that the bodies of the plant (*Acanthus mollis*) had ruptured, and, in the act of doing so, had scattered their seeds with considerable violence all over the room.

What had happened was that during the time the seed capsules had been lying in the box the dryness of the room had brought the ripeness of the fruit up to the required degree of elasticity for the capsule to burst.

A similar interesting and remarkable incident is quoted by the botanist Kerner. " On the heights of the Kahlenberg, at Vienna, at the edge of the wood, grows an under-shrub which bears the name of *Dorycnium herbaceum*. It is one of the Papilionaceæ, and develops spherical one-seeded fruits, which ripen in October. I once collected from this plant several twigs laden with fruit, for the purpose of a comparative investigation on which I was engaged, and brought them home and laid them on my writing-table. Next day as I sat reading near the table, one of the seeds of the *Dorycnium* was suddenly jerked with great violence into my face. Shortly afterwards I saw a second, third, fourth, and ultimately about fifty seeds let fly from the small clusters of fruit, and each time I heard a peculiar sound which accompanied the bursting open of the fruits and ejection of the seeds. The rays of sunshine from the window had evidently heated and dried the fruits, and occasioned this surprising phenomenon."

These examples may serve as an introduction to the idea of the dispersal of seeds and fruits by means of special mechanisms evolved for that purpose. First of all we may note some examples of what are known as the sling-fruits, or expulsive fruits, of which the one referred to by Goethe Acanthus—is a large group. When the fruits of these plants are perfectly ripe, the covering immediately around the seeds becomes extremely tense and stretched: indeed, to so great an extent is this the case that the tissue is actually forced to open or burst at certain parts, and the result of this is that the segments which are left contract suddenly. In so doing they roll themselves up, and the seeds, which adhere up to this point to the segments, are expelled with the violence of the

contractile movement. As a rule, it is not the whole fruit that is thrown off by these sudden movements, but merely the seeds,

SEED CAPSULES OF ACANTHUS, SHOWING THE EJECTION OF THE SEED

although considerable difference obtains in different species in this particular. In spite of the many variations in the contrivances in plants evolved for this object, the result is always the same—namely, that the ripe seeds are hurled to a given distance—which, of course, varies—and larger numbers are enabled to survive.

A very striking plant in the sling-fruit group is that known as the squirting cucumber (*Ecballium elaterium*). The fruit of this plant looks rather like a small cucumber covered over with bristles and carried by a bent stem. This latter is prolonged into the inside of the fruit in such a way as to act almost like a cork to a bottle. When the seeds within are ripe, the part of the plant substance immediately around them becomes softened and gelatinous, and this has the effect of loosening the connection of the stem, or cork, with the interior. At the same time, the cells composing the wall of the fruit swell up, become turgid, and are at high tension from the endeavour to expand. Indeed, their expansion is only hindered by the firmness of the tissue immediately round the stem, or cork. When this becomes sufficiently softened, so as to loosen the latter, the connection between it and the fruit is broken, and at that time the layer of cells, which is extremely tense, becomes expanded. The total result of these changes is that the interior of the fruit is subject to great pressure, and to such an extent is this the case that the seeds within are driven out through the aperture, which was formerly corked up by the stem referred to. They are, as it were, squirted out by a propulsive force, and this gives the name to the plant itself.

The common wood-sorrel is another of the sling-fruits that expels its seeds in a somewhat similar manner. In this case, too, the bursting of the portion of the plant which causes the expulsion is caused by the high tension produced by the swelling of certain cells covering the seeds. In the case under notice, it is the seed-coat that becomes thus tense. The external layer of the pericarp is at the last stage unable to resist the pressure within, and ruptures in such a way as to sling out the seed through the aperture made by the rupture itself. In all these cases "the cause of the expulsion is the turgidity of cells, or the swelling up of cell-membranes with a concomitant maintenance of a state of extreme tension in a particular layer of tissue situated in the wall of the fruit." 7,889

There are, however, quite other arrangements that bring about a similar result. In some cases there is a special layer of the wall of the fruit which, when it ruptures, curls or rolls itself up, doing this so quickly that the seed, or seeds, attached to this portion are thrown away from the plant to some distance. In this case the mechanism is something like that of a spring suddenly released. A case in point is that in connection with the fruit of the Marsh Crane's-bill (*Geranium palustre*), a plant thoroughly familiar, in all probability, to most readers. If this be examined, it will be noticed that the carpels, which are five in number, are swollen in the shape of a hemisphere at their base, tapering at their free ends in the form of a long beak. When the seed is ripe, the tissue composing this long structure dries up, and the beak separates itself into the five component parts, curling up as it does so, just as a watch-spring curls. This separation of the parts has the effect of exposing the cavity in which the seed lies, and the further effect of the watch-spring movement throws away the seed to a considerable distance.

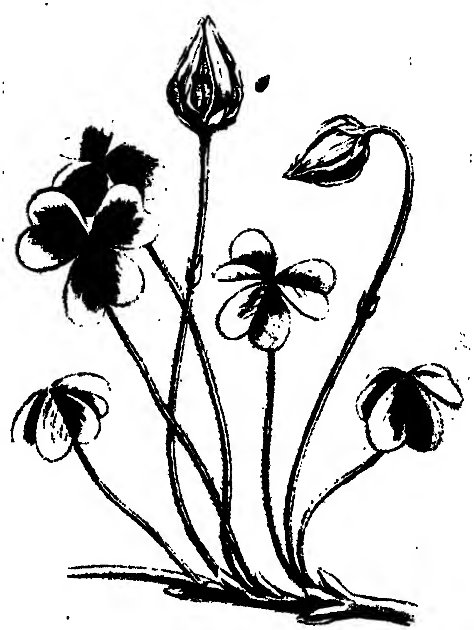
A somewhat similar performance is that carried out by certain violets, which possess fruits within a capsule that separates into three distinct valves. These valves somewhat resemble the shape of a boat, the seeds within being arranged in two rows, like the rowers. Again we have the rupture

of a special layer of the fruit-wall, which is exerting pressure on the seeds within. The rupture of the capsule ejects the seeds to quite an extraordinary distance, the seeds following each other in regular succession from one end to the other, and the carpels, or boats, emptying themselves and their seeds, or crew, one after the other.

In quite a large number of other plants the fruit is provided with a number of valves, which twist themselves into a spiral at the moment when the capsule opens, the number of coils in this spiral depending upon the length of the tissue concerned. Other contrivances of a somewhat similar nature are to be seen in the Eschscholtzia, where the entire fruit is slung away; in the Stork's-bill, and in some of the umbelliferous plants. In these cases, and in others similar, the arrangements of the growth of the plant are such that, when the time comes for slinging out the fruit, no other structures are in any position to interfere with its success. For example, if the fruit in its early stage is concealed under leaves, or carried on stalks with a downward curve, as is the case in the wood-sorrel and the violet respectively, these stalks assume such an attitude as

SEED DISPERSAL OF SQUIRTING CUCUMBER

provides for the greatest range of dispersal at the moment of ejection. Moreover, the seeds themselves are of such a shape that they offer as little resistance as possible to the air, and this is attained by their being either round, oval, or bean-shaped.



THE EJECTION OF WOOD-SORREL SEED

It might be thought, at first sight, that the smaller and lighter the seed, the farther would it be projected, but, as a matter of fact, the case is precisely the opposite. The large and heavy seeds are thrown much farther than the small and light ones. Of course, the distance to which seeds are slung or hurled by these special contrivances is quite infinitesimal when compared with such agencies of dispersal as wind, water, and animals. Probably this is the reason why these arrangements are somewhat exceptional. No plant, as far as we are aware, is able to project its seeds to a distance of more than forty-five or fifty feet, and it is a curious and interesting fact, illustrating once more how Nature produces structures adapted to special environments, that the few plants, comparatively speaking, known as the sling-fruits are chiefly found to inhabit localities sheltered from wind.

An interesting refinement of this process of dispersal, and one which renders it even more certain and effective, is found in sling-fruits whose capsules are developed in such a way that when they are at the proper stage of ripeness they burst open upon the slightest provocation. A very

slight touch from the outside is sufficient to relax the tension of the capsule, and cause the seeds to be thrown out *in the precise direction of the object which came in contact with the capsule.* This object is usually a passing animal, and the result is that the seeds are slung at the animal itself, and, surrounded as they are by a soft and sticky substance, some of them, at least, adhere to the skin of the creature. The seeds thus adhering to the animal's coat may, or may not, be irritating to its skin. If they are, they will be carried by the animals to some distance, and endeavours will be made to rid themselves of the irritating particles by rolling on the earth, rubbing against trees, or some other mechanical means of removal. If they are not irritating, they will be carried about by the animal until ordinary causes of friction determine their escape. But in either case the contrivance on the part of the plant to secure the dispersal of its seeds is obviously an eminently successful one.

So much for the consideration of the mechanical means adopted to scatter seeds in what we have termed the sling-fruits. Be it noted in leaving this group that in all these cases the forcible expulsion of the fruit is made possible either on account of the loss of water in certain layers of cells, or by other cells becoming more turgid.

THREE SEED-PODS OF THE SWEET VIOLET BURSTING OPEN

Next we may turn our attention to an entirely different method of seed-scattering —namely, the elasticity of the stalks or stems on which certain fruits are carried. These stalks and stems are kept in an enforced attitude by external agencies, and, being extremely resilient, should the compelling influence cease to operate they spring back from their elasticity into a different position, and this rapid change of attitude throws the seeds they carry to a considerable distance. The whole mechanical arrangement suggests the action of the ordinary catapult, and hence the name *catapult fruits* has been given to plants that disseminate their seeds in this manner.

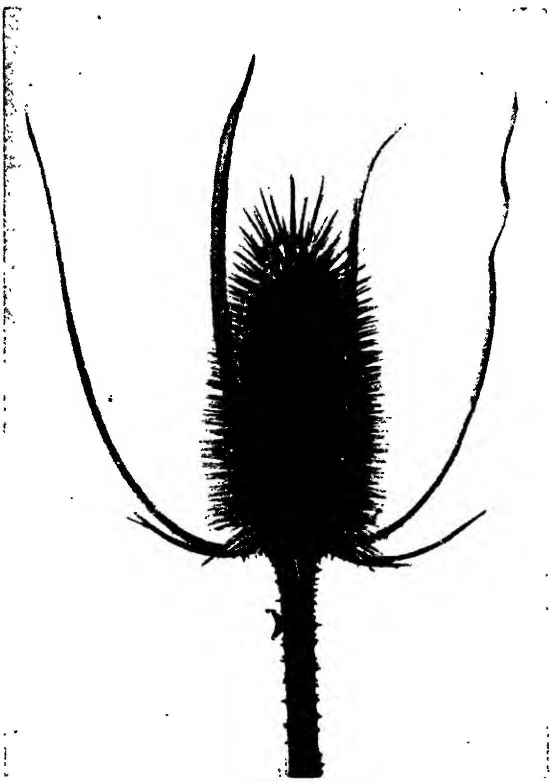
Some of the simplest examples of thi kind of mechanism are to be found in th common order of the *Compositæ*, where th fruits are carried upon somewhat lon stems held upright, and distinctly elastic The fruits in these flowers are small, an when they are ripe they are to be found i the middle of a disc, which has a number o scales round it. In some other cases the are deposited in a kind of basket-shape receptacle, but in either case the fruits ar unable to escape from the position in whic they ripen unless some outside force i applied. This force is commonly found i the wind, or the result may be well attaine by an animal rubbing against it. In eithe case the stem, which bears the receptacl on which the fruits lie, only requires to b bent down by the forc of the wind, or by th contact of a passin animal, in order t bring about the scatter ing of the seed b means of its own powe of elastic recoil in it effort once more t assume the erect atti tude. As this recoi takes place, the rip fruits are scattere from the central dis on which they lie.

In some othe members of the sam order there is a curiou arrangement of scales which are also elastic and in some the fruit are so arranged i compartments, as i were, that any dis turbance of the whole structure moves th seeds higher and higher up these scales unti they reach the summit, where they ar naturally discharged, and the movement of the stem in the wind cause them t describe a curve in the air.

In still other *Compositæ* the seeds ar carried in a kind of basket, which is close as long as the weather is moist, but open widely in hot, dry weather. Out of these baskets the seeds are thrown by means o the swinging stem, and in all these cases i is to be observed that the aperture from th fruit capsule is directed upwards, and is onl open in dry weather. It follows that th seeds lying at the bottom cannot escap except when the elastic stem which carrie the receptacle is disturbed by the force o

the wind, or when some other external influence sets it in motion.

Some of the fruits in the order of the *Labiatæ*, which includes many of our common plants, have a particularly interesting mode of dispersal, especially in cases where the fruit is deep down in the calyx. This latter structure is somewhat tube-shaped, and is supported by an elastic stem. If pressure be applied to the points of the calyx, the elastic stem, of course, bends in response to the force applied. On account of its elasticity, however, it immediately flies back to its original attitude when the pressure is removed, and in doing so the fruits, which are like small nuts and rounded in shape, are fired out of the catapult, as it were, with astonishing force. Not only so, but they are fired out in a definite fixed direction by means of a groove, acting in a very similar way, and with a similar result, to that in the barrel of a rifle which determines the flight of the bullet. The force of the wind, or the contact of an animal, or the weight of the water from rain may bring about the desired result.



THE HEAD OF TEASEL AT THE FRUITING STAGE
The vibration of the stem causes the seeds to jerk out of the scales which act like spring-boards

Even with all these marvellously perfect arrangements for the securing of seed dispersal, Nature is by no means at the end of her resources. Certain fruits and seeds are so constructed that they are able to travel over the surface of the ground, when once they reach it, almost as well as if they had organs of voluntary locomotion. We refer to those fruits which are described as *creeping* and *hopping* fruits, terms which express the idea, or at least suggest, that the fruits themselves can creep or hop about on the ground as if they were animals. Such fruits as these are furnished with a number of bristles, which readily absorb moisture from the surrounding atmosphere. According to the amount of moisture present in the air, and so varying in its amount of absorption, these bristles change their shape and arrangement, and in so doing they actually cause the fruit to move along the ground just as definitely as if they were the limbs of a spider.

The principle simply is, therefore, that different parts of the structure alter their relative positions one to another, and so produce the creeping movement. There is one further necessity, however, before such a mechanism could be perfectly successful, and that is that the bristles, by means of which it is carried out, must have some means of getting a grip upon the surface over which they are moving. This means actually exists in the shape of a number of small teeth like the edge of a saw, all pointing in the same direction, and having the effect of absolutely preventing movement in a backward direction.

It must not be supposed, however, that the distance of dissemination attained by means of these creeping or hopping arrangements is to be at all compared with the means of dispersal afforded by wind and water and animal carriers. As a matter of fact, the result of these movements is generally to cause the fruit to be held captive in some corner from which it cannot escape, and it is possible that part of the function of these bristles is to afford a means of attachment to the earth until the seed takes root.

We have seen that certain fruit capsules only open and allow their fruits to escape under the action of dryness and sunshine. On the other hand, there are some that open only upon becoming wet, as, for

instance, by means of rain. In these cases it is doubtless an effort on the part of the plant to prevent the seeds being utterly dried up and lost, because plants exhibiting this phenomenon are chiefly those of dry, arid districts. In such cases, if the wind itself were able to disperse the seeds, they would probably never give rise to new plants; but, having an arrangement requiring the presence of water, as in rain, to set them free, they are also assured of finding sufficient moisture to start their growth at the time they are set free.

In a former paragraph we noticed the action of water in the shape of the ocean currents and rivers in dispersing plants, or parts of plants, and the same thing appears, perhaps with even greater force, in connection with fruits and seeds. It is perfectly obvious that a large number of air-borne seeds and fruits will be blown, sooner or later, into streams and rivers and the sea, and will be carried by these agencies to far-distant parts, where they may start new growth. Doubtless many of these perish on their enforced journey, and others will find themselves in an unfavourable environment when they are once more deposited. We are here speaking of the dispersal of the seeds of land plants, not water plants. Others, however, may be carried immense distances in this way, and be months upon the journey, and botanists have made some experiments with a view to ascertaining how long certain seeds could be thus immersed in the water of the sea without losing their germinating capacity. These experiments have shown that for the plants tested the seeds are perfectly sound and able to grow after being no less than a whole year in the sea.

THE FRUITS OF THE CRANE'S-BILL

Needless to say this means that such seeds might be transferred from one end of the world to the other by means of some of the great ocean currents, provided they have

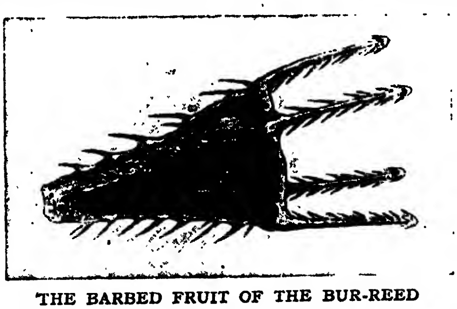
SEED CAPSULES OF LYCHNIS FLOSCUCULI CLOSED AND OPEN

THE CREEPING SEED OF AVENA

A SEED WITH SAW-LIKE RIDGES

the capacity of floating in the salt water. This is an extremely important point, and restricts the operation of this method of seed dispersal to a much greater extent than would otherwise occur. As a simple matter of fact, there are quite a number of fruits and seeds which, when placed in water, will float on the surface, but the number that will continue to do so for anything like a protracted period of time is comparatively much smaller than might be expected.

Some of the fruits, of course, have external coverings of such a dense nature as to render them impermeable to the action of water, and to cause the fruit to float for an indefinite period. Frequently, also, in this outer coat is a certain amount of air, such as is intermixed with the fibres of the cocoanut; and this, too, helps the fruit to float buoyantly.



THE BARBED FRUIT OF THE BUR-REED

The photographs on these pages are by Messrs. Hinkins & Son and J. J. Ward

A word must be said here about the curious manner in which water disperses the seeds in lakes and ponds where currents are absent. There is, nevertheless, a quite definite movement in such waters, even if it cannot be described as a current, and this movement is established in relation to a different temperature at different depths. This, of course, produces a vertical movement, and would not aid very much in the transmission of seeds from one shore to another. This last is brought about by the action of wind upon the surface. It will be found, if a careful examination be made, that a large number of plants dwelling in the neighbourhood of marshes and lakes develop fruits contained within a capsule which floats by means of air within it. Among these may be mentioned marsh plants, such as the sedges, the fruits of the water-plantains, of the flowering rushes, and some of the water-lilies. In all of these it is a combination of wind and water which enables the dispersal of the fruit to be brought about, the fruit being so constructed as to float upon the water, which, however, in the absence of currents, requires the agency of the wind to move the seeds along its surface.

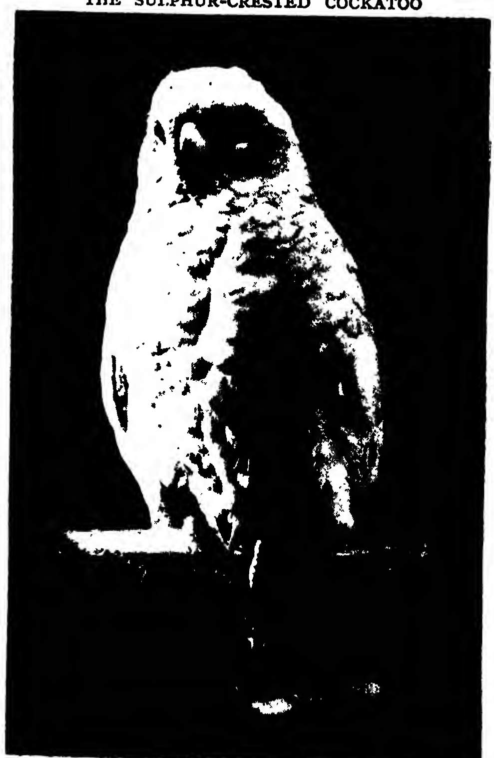
With these examples we must bring to a close our study of the dispersal of seeds and fruits, remembering, however, that what we have said must be regarded merely as, first, a general statement of the principles by means of which necessary seed dispersal is brought about; and, secondly, a brief account of some only of the special instances that may be observed. Space forbids our entering into further detail, and we must content ourselves with simply stating that there are innumerable other definite and special contrivances of great ingenuity and interest planned for a similar purpose.

GORGEOUS BIRDS OF THE ANTIPODES

LEADBEATER'S COCKATOO

THE SULPHUR-CRESTED COCKATOO

THE ROSE-CRESTED COCKATOO



THE BAR-EYED COCKATOO

The photographs on these pages are by Cherry Kearton, Cyril Grant Lane, and others.

A FINAL REVIEW OF BIRDS

To what Extent Have Birds a Colour Sense, and How Does it Operate in Sexual Selection?

BIRDS THAT ARE PROUD OF APPEARANCE

NATURALISTS are not in complete agreement as to the precise part played in the animal kingdom by sexual selection, a point that presents itself to us in this concluding chapter on birds, which will embrace some of the most beautiful of the feathered creation. By sexual selection is meant, of course, a constant preference by the female for the more brilliant, or otherwise bodily distinguished, male. As birds assume their most brilliant plumage for the breeding season, and it is then that their most fantastic and bizarre displays are made to attract the attention of the females, it has been held that here is direct evidence of the operation of sexual selection, inasmuch as the brightest, handsomest male would become the chosen of the female. But choice on a basis of ornament and attractiveness implies a high degree of æsthetic development on the part of the females of animals of whose development in this line, it is urged, we have no other proof.

There seems little doubt that much of the gorgeous ornamentation of certain insects and shellfish is obscured from the female's sight; that the evolutions of dancing swarms of winged insects—dances undertaken, it has been supposed, to excite the admiration of the females—are performed only by males with the females far from the scene; that the chorussing of male katydids in a shrubbery results in each individual female hearing the song only of the male nearest her; that the gleam of the darting firefly is detected only by the female past whom he flashes; that the gorgeous characters of certain beetles, beautiful in death, are hidden during life by the accumulated filth of the garbage in which such insects find their food.

Darwin records eight cases among birds in which he recognised an obvious choice by the female. Since Darwin's time, it is stated by Jordan and Kellogg in their admirable volume, only half a dozen cases have been noted, and these doubtful. That seeks to prove too much; for no writer is acquainted with all the observations that are made which do not find their way into print. If the assumption be wrong that sexual selection is a process existing only in the imagination of Darwin, of what value, then, is the gorgeous plumage of birds of paradise, of humming birds, of pheasants, and others with which we are here to deal?

Mr. Pycraft, summarising evidence gleaned from many quarters, holds that sexual selection may operate in such a manner that the secondary sexual characters of the males—the lovely plumes and so forth—play only a subsidiary part. These may have resulted not from the choice by females of the handsomest males, but from the choice of males which have been most vigorous and ardent and valiant, birds which would naturally show greater attractions than their rivals. The healthiest bird is always best and brightest in feather. His health and spirit and his determination to win a mate are the things that matter; and the quality of plumage may be only an accompaniment.

It is not the brilliant bird alone which displays; birds of sober feathers strut and curvet, bow and prance. "The evidence seems to suggest," says Mr. Pycraft in his valuable new work on birds, "that the evolution of resplendent plumage is not to be attributed to the effect of the selective action of the female—to the choice, by the female, of the most effectively coloured among her suitors. This development of colour, or of decorative plumage of any kind, of secondary sexual characters, in short, must be regarded, apparently, as due to the unchecked growth of such characters, as they appear, seemingly

fortuitously, in the germ plasm. They are a by-product of sexual selection, in the sense that they of necessity take part in the sexual demonstrations of the desire to mate. But neither the brilliant colours nor the excessive development of feathers in this or that area . . . can be attributed to this cause. These are germinal variations which have survived, and may have attained exaggerated proportions, because they formed no obstacle to the struggle for existence, and in this they resemble all other fortuitous variations."

The question is one of some complexity, and not dogmatically to be dismissed. Those who deny æsthetic recognition in birds will not have a general following. Undoubtedly discrimination is exhibited in the choice of materials with which nests are embellished; with which the satin bower-bird makes its playing-hall; and in the thefts of brightly-coloured articles of certain birds. Proceeding from the general to the particular, in citing certain aviary experiences one is aware, of course, of the profound modifications which result from the domesticity of birds. Nevertheless, the evidence of a large aviary, in which the conditions are sufficiently favourable for birds freely to breed and rear their young, is not wholly to be despised.

First as to colour-sense. At one time the aviary in question included a pair of Java sparrows and a pair of common turtle-doves. Apparently the colour of the doves attracted the Javas as that most nearly approximating to their own, for during two or three years the four roosted in the following manner: the doves settled for the night high up, just beneath the roof of the aviary. When these two had thus established themselves the Javas would approach. One would settle upon the back of one of the doves, and the other would rest beneath the breast of the same bird. The positions never varied until the doves were given away. The Javas grew old and died, and their places were taken by a second pair, in the same year that a pair of pretty little bronze spotted doves were introduced into the aviary. Before a fortnight had elapsed an association sprang up between Javas and doves. The latter, which were moulting when first bought, formed a habit of hiding away in the inner aviary, while the Javas, in common with

THE SATIN BOWER-BIRD AND ITS DECORATED PLAYGROUND

90 per cent. of the fourscore other occupants, preferred the thickly ivied walls of the aviary, which walls abut upon the large open-air flight.

At certain times the doves perch out in the open after feeding, and invariably, if there be a chill wind blowing, the Javas quit their nook in the ivy, fly to the doves, and nestle, one under the breast of one of the larger birds, and the other between the latter and its mate. Of none of the other birds do the Javas take the least notice.

The colour-scheme of the breast of a Pekin robin and of a female golden-breasted amadavat is pretty similar, and for weeks a hen of the latter species, bereaved of her mate, perched and roosted between a pair of the robins, her tiny golden breast shining between their plump fulness like a half-sovereign between five-pound pieces. In due course a new mate was secured for her; but though he sang gallantly enough to have charmed the heart of a Cochin-China hen, she harried and pecked and drove him quite unconscionably, until the very week in which the present chapter is written. He now began rapidly to moult into his nuptial plumage. Wings and breast are blushing scarlet, and the lady, without an effort on his part, is won. He has made no perceptible advances, but her heart is his, and the Pekins have lost their bedfellow. But before he can quite appreciate his fortune, a rival for his affections appears in the form of a tiny lavender finch, who neglects the trimmest little mate in the world for the sake of the scarlet and gold and the white spots of the resplendent amadavat. So much by way of reference to what may be termed the colour-sense in birds, as distinguished, in two out of the three instances, from the pairing instinct.

A WEAVER-BIRD AND ITS NEST IN BRITISH EAST AFRICA

Still more striking is the example from another aviary of a hen bullfinch, which when an orange bishop weaver assumed the superb nuptial plumage in favour of which he discards his ordinary, sparrow-like garb set her cap most determinedly at him, wooed with all the fervour of a lovesick male carried food to him, and by every artifice sought in vain to engage his affections Towards the end of his gaudy period he showed signs of reciprocating, but it was too late Orange and black feathers began to yield place to the sober brown of his normal equipment, and forthwith the

affections of the bullfinch waned; he became to her no more than the sparrow on the housetop.

Of the selection by the hen, canaries at times afford clear proof. In the first-mentioned aviary are several of these birds. One of them, a shapely little Norwich hen, suddenly set her affections upon a representative from the Hartz Mountains, who was already plighted to a huge Yorkshire hen. The little lady of Norwich behaved with termagant violence. She pecked and beat both male and female whenever they approached each other, and eventually claimed the male for her own. Sad to relate, when a wonderful little songster from St. Andreasborg was introduced into the aviary, she was prepared to discard her hardly-won mate and set up house with the new-comer. She was promptly packed off with her spouse to the breeding-cage; and since her release from the cares of nesting has evinced an extraordinary dislike for the St. Andreasborg canary, which had in the meantime been appropriated by the Yorkshire hen aforesaid.

Just one other aspect of the question — as to the perception in the male of beauty and its absence in the female. A couple of linnets were mated and about to build, when by some mischance, either in battle or by collision with some undiscovered danger-point in the aviary, the

A GREEN PARRAKEET

THE CUBAN MOCKING-BIRD

hen came by a bad accident, damaging the lids of both eyes and tearing the feathers from her head. She was tenderly doctored, and recovered her health, but not her good looks. Her mate then utterly cast her off, and did not tolerate her near him. She

THE GREEN HANG-NEST

really did look rather a fright — like a diminutive owl half way through a desperately difficult moult — and he seemed to recognise her disfiguration and to look upon her with loathing. After her moult, feathers reappeared upon the head, and forthwith the mate made his peace, and became the most assiduous of swains.

We must pass, however, to consideration of the actual birds most famous for beauty and display. First of these are the birds of paradise, of which, although their range is limited to New Guinea and the adjacent Papuan islands, with one genus in the Moluccas and three genera in North Australia, there are no fewer than fifty species—a remarkable example of the variation of a type peculiar to a comparatively small area. The females are plain, dull-looking birds, but in the males luxuriant beauty and fantastic embellishment find their most lavish expression. We know something of a few species from observation in the London Zoo; and the hats of soulless women have familiarised us with the stuffed, distorted figures of others. But only the man who has seen these birds in their native haunts has any conception of the splendour of their appearance and the novelty of their performances where they roam free—feathered gems in a tropical setting.

We may fall back upon Russel Wallace's

description of this unparalleled group of birds. "In several species," he says, "large tufts of delicate, bright-coloured feathers

THE BLUE TANAGER

spring from each side of the body beneath the wings, forming trains, fans, or shields; and the middle feathers of the tail are often elongated into wires, twisted into fantastic shapes, or adorned with the most brilliant metallic tints. In another set of species these accessory plumes spring from the head, the back, or the shoulders; while the intensity of colour and metallic lustre displayed by their plumage is not equalled by any other birds, except perhaps the humming-birds, and is not surpassed even by these."

THE GREEN ORIOLE

The student will consult a standard work on natural history for detailed description of such animate marvels as the twelve-wired bird of paradise, the rifle-bird, the long-tailed, the Alberti, the gorget, the great, the red, the king, the Wilson, the six-plumed, the standard-wing, the superb, and other members of the paradise bird group; and, remembering that these wonderful creatures are allied on the one hand to the crows, and on the other to the bower-birds, will realise afresh how infinitely diverse are the variations resulting from one group of birds originating in a common stock.

The bower-birds, as a fact, are included in the birds of paradise family, and are famous, of course, from their habits of constructing bowers or playing-houses in which the males assemble for recreation. These bowers have no connection with the nests, and are decorated, some with flowers, newly gathered day by day, by bright feathers of birds, by metals, by bleached bones and decorative stones, and any other thing portable which appeals to the instinct of the bird. In the case of both the satin and the spotted bower-bird these runs or bowers are the rendez-vous of many birds, and some are used year after year, so that stones and bones employed for decorative effect, carried from distant river-bank or deserted camp of native, aggregate half a bushel at each entrance to the bowers.

As, according to some authorities, the birds of paradise are related to the crows, so are the drongos of Southern Asia, Australasia, and Africa. One species, indeed, is known as the king-crow, a fork-tailed bird of pugnacious habits and crow-like plumage, enriched by a deep metallic green. This drongo is a match for most of the birds of prey that come his way, and is decidedly given to bullying, yet he is mimicked by a cuckoo, the fork-tailed drongo-cuckoo, which not only mimics the king-crow, but actally lays its eggs in the crow's nest. The drongo has been seen to kill an adult drongo-cuckoo what time it has been rearing juvenile drongo-cuckoos in its nest.

A more notable drongo is the racket-tailed, which is a wonderful mimic of bird and beast. They declare at the Zoo that their specimen can imitate anything, from a jackass to a canary, while it has sweet,

THE LONG-TAILED WHYDAH-BIRD

flute-like notes of its own. With training, these birds become accomplished talkers, and match the delightful mocking-birds of another continent. The adjective here applied stands, perhaps, in need of modification. The typical mocking-bird turns its mimetic art to anything that it may happen to hear, from the uproar of a sawmill to the loveliest note of bird. But others, such as the cat-bird, are an unmusical nuisance. Bird-cries are really as varied as bird-hues, the thrilling scream of the eagle, the lion-like roar of the ostrich, the mewing of the black-headed mannikin, and the bee-like buzzing of the spice-birds representing great divisions of vocalisation, filled in by varieties of song and call as numerous as the species by which they are uttered.

The finest of mimics with which the majority of us are acquainted are, of course, the parrots. Of these, the red-tailed African greys (*Psittacus erithacus*) are the most proficient, but here and there, in almost every species, the mimetic faculty is found more or less highly developed. Let it be noted here, in the name of common sense, that the idea that other birds—the starling, for example—can be made to talk by slitting the tongue is as preposterous as it is barbarous. The tongue has nothing to do with a bird's talking. The voice of the bird is produced from the syrinx, which is low down in the windpipe.


A LYRE-BIRD DANCING

No man ever thought of slitting a parrot's tongue, possibly because all the birds of this family have prodigious biting power. Even the little budgerigar, the grass or zebra parrakeet of Australia, can make its mandibles meet in the flesh of quite a friendly hand. The parrots rank as among the most intelligent of birds. It would be surprising if from so great a group—there are some eighty genera, and five hundred species, scattered over the tropical and sub-tropical regions of the Old World, with one genus in the New World—it would be strange if among so numerous an assemblage examples of high intelligence were not found. The mere talking to which they can be trained is nothing. The wisdom of the bird, judged by this standard, is inferred from the degree of appositeness with which it utters its phrases. But inasmuch as the average parrot-sayings have as a rule absolutely no relevance to anything on earth, the speech of the bird may be taken as purely automatic, meaningless, and of no more account to the parrot than the thousand and one screeches with which it enlivens the day. A much more notable thing in the equipment of the parrot than this sharing with other birds the power to imitate human speech is this—that it is one of the few birds which have learned to use the foot as a hand.

Not only does this refer to the use of the foot as a means by which to climb: the parrot holds its food in its claw. Many birds use the foot, or feet, to hold down the food which is being picked or torn, but the parrot makes the nearest approach to the higher animals in this matter. Parrots live to a great age. Over what space of time reproduction is possible has never been ascertained, but during the present year a case has been recorded of one, known to be over forty years old, producing eggs in captivity for the first time, after over thirty years in one home.

Among the species that take with perfect indifference to aviary life, the budgerigars are the best example. It is only by home observation that one learns into what small space these seemingly large birds can pack themselves. In one of the Selborne Society's nesting-boxes for tits, placed in the aviary specially with a view to the accommodation of some of a numerous company of waxbills, one pair of budgerigars set up housekeeping, and brought up three lively youngsters; while in another tiny receptacle, in which a stranger would have thought a budgerigar could not turn, a second pair have successfully reared five at a sitting.

As stress is laid upon the feeding of the hen hornbill by the male, it may be mentioned that during the nesting period the male budgerigar feeds the hen from the time that she begins to incubate the eggs, and scarcely permits her to take a mouthful of seed on her own account, but pecks and clutches and drives her until she scurries back to the nest. From the time that the first young one is hatched she appears to

take her food entirely from her mate—food for herself and for the nestlings. The mother of the three aforesaid died when the eldest of her brood was only a fortnight old. The male bird then took over nursery duties, fed the youngsters, and brought them up in the way that they should go. He still fed them when, perfectly equipped and excellent fliers, they emerged from the nest; but at the same time he evinced unwarrantable affection of demeanour towards the indignant mother of the other five in the little home across the way. Quarrelsome when the females are about, the males are the best of friends when their better halves are safely housed, feeding and roosting together in perfect amity.

THE BLACK HORNBILL

Passing away to another group of birds, we note for a moment the orioles, birds of beauty and of song, scattered over temperate Europe, Africa, China, India, and Australia. The golden and green orioles are the best known. The Baltimore oriole is grouped with the troupials, which are regarded as the starlings of the New World, although intermediate in structure between the crows and finches. The Baltimore and the cassiques are representatives of the hang-nests, birds which construct curious pendant nests, elongated, wide at the base, narrow at the top, and admirably woven, and placed so that, while no predatory animal can negotiate the slender branch on which the nest is hung, no bird of prey can enter the diminutive opening by which alone access is obtainable. Allied to these are the bobolinks and cowbirds, the latter in process of becoming parasitic upon other birds, whose nests they seize, or insinuate into them their own eggs after the fashion of the cuckoo.

THE GREEN-BILLED TOUCAN

The handsome builders of admirable nests include, of course, the notable weaver-birds, the males of which construct the most perfect of dwellings for the sheer joy of building, even if their structures are not in the end utilised as nurseries. Among these birds we have many gorgeous specimens—the masked, the bishops, the grenadier, the paradise whydah, the combassoo, etc., related birds, though not all notable as nest-builders. All, however, make remarkable plumage changes, from the dull, sober tints, resembling the constant costume of the hen, to the most resplendent scarlets, orange, amber, and black, and, in the combassoo, the most lovely of indigo-blues. The majority of them are familiar to aviarists, for they are as interesting as they are hardy.

No bird is better worth watching than a robust weaver in nuptial plumage. The masked weaver flutters like a huge moth; the whydah flounces through the air with the swagger and bumptiousness of the inoffensive braggart that he is. But within the frame of the grenadier is resident as much

vice as a bird well can hold. Apparently this bird does not attain full sexual maturity until his fourth year. In the third year he for the first time undergoes his change of colours; in the fourth he is perfect—and a villain. Until the fourth year he is peace and placidity embodied, but then he becomes a sort of swashbuckling tiger in feathers, flaunting through the air in undulating swoops, displaying his blackened wings like a vulture, raising his noble orange crest, and puffing himself out with conspicuous pride and effrontery. Only the bird that will stand up to his constantly repeated attacks escapes persecution. If he can once get a bird on the run he is happy, even a lusty red-crested cardinal, equally with Java sparrows, various buntings, and other weavers, being among his victims. This bird is at his best when a stranger enters the aviary. At such a time the majority of the birds fly wildly to and fro. The grenadier ignores the intruder, and simply "makes hay," as we say, of all the fugitives.

We must pass by the manifold beauties of waxbills and tanagers, honey-creepers, and sugar-birds, the attractive garb and characteristics of the grosbeaks, and the splendour of plumage in the lyre-bird—another of the birds in which the mimetic faculty is highly developed. We come to the humming-birds, the supreme avian wonders of South and Central America. Allied to the swifts, they constitute over a hundred genera, comprising some five hundred species. Ranking as equal firsts in point of beauty with the birds of paradise, incomparable in flight, they hang in the air over a flower whose nectar they are extracting with long, extensible tongues, and poise so wonderfully that, while the body is momentarily motionless, the wings beat with such rapidity that the human eye cannot follow them, but detects only a greyish blur. They can leap from such a position vertically higher into the air, and, as if by one and the same impulse, transport themselves a distance of forty or fifty yards to right or left with such speed that one is only conscious in one and the same second, as it seems, that they were here and are gone.

The birds vary in size as in plumage, in shade and proportions of beak, in form of tail, from the simplest grouping of feathers to the remarkable adornments of the long-tailed and the racket-tailed. These birds alone seem to have mastered the art of flying backwards. For all their beauty, humming-birds are pugnacious little creatures, and fight among themselves—as *all* birds fight.

MALE AND FEMALE BLACK HORNBILLS OF WEST AFRICA

Another famous family of South American birds, the chatterers, embraces such curiosities as the umbrella-bird, so named from its singular crest composed of straight, elevated feathers, the extremities of which curve outwards, and form an elegant line of drooping plumes, a further singular arrangement of feathers, springing from beneath the throat, forming a loose lappet; the bell-birds, whose name refers to the startlingly bell-like note which the birds utter; the cotingas, of which the males are specially brilliant of plumage; and the cocks of the rock, gorgeous birds, the males distinguished by a striking, helmet-like crescent of feathers forming a semi-circular crest. One of the chatterers, the Pompadour, conceals a fragment of history in its title. One of the most beautiful of its family, this bird was included among a number of others despatched from Cayenne for Mme. de Pompadour,

only to fall into the possession of a British frigate. The birds changed hands, but the title remained unaltered.

The woodhewer family is another South American group, of which the oven-birds are the most interesting, from the singular form of nest they construct. This structure is of mud, strengthened by the addition of fibres and horsehair to prevent cracking. It consists of two compartments, formed by a dividing wall reaching to the oval roof, but possessing an opening at the inner extremity, giving admittance from chamber to chamber. Lined with soft, dry grass, the nest is one of the most admirable and durable examples of bird architecture, and is an affair of substance, too, containing materials weighing from eight to nine pounds.

THE HOOPOE

We leap hence from these accomplished builders to another parasitic bird, the African honey-guide, which deposits its eggs in the nests of other birds, and, moreover, claims the assistance of man in gaining a livelihood. Upon seeing a human being approach it will fly towards him, and seek to attract attention. On being followed it will lead the way to a tree in which bees are collected, claiming its reward in the shape of the bee-grubs which the nest contains. As the honey-guide will conduct its human ally to the nest of bees owned by a native as readily as to wild bees' abodes, the results are sometimes embarrassing. The honey-guides constitute a distinct group to themselves. They precede the barbets, which link the bizarre and gaudy toucans with the woodpeckers.

ELLIOT'S PHEASANT

Were it not for the existence of the African and Asian hornbills, the South African toucans would pass as an unparalleled freak. The beak of the toucan is preposterously out of proportion to the size of the bird, while the colour-scheme, alike of plumage and beak, is garish and startling in the extreme. Subsisting on a diet of fruit and vegetation, eked out by small birds, mammals, and insects, the precise need for so huge a beak is not readily recognisable, though the extreme lightness of its structure, which makes it no impediment to the strong and graceful flight of the toucan, is very noticeable when one of these birds is examined.

The prodigious beak of the hornbill serves as a weapon of defence against the birds' many enemies—monkeys and tree-haunting carnivorous lizards among them. It is of great service as a trowel for plastering with mud and gums the entrance to the nest. But perhaps its chief use—in the fruit-eating species, at all events—is in enabling the bird, which is a poor flier, to reach food growing high upon slender branches that would not bear the weight of the bird should it manage to alight upon them. The female is imprisoned while brooding, but not from any fear on the part of the male that she should desert her eggs; she undergoes a complete moult at this time, and would be helpless against her enemies were she not thus barricaded in. Only a small opening is left in the wall at the

A NOTABLE EXAMPLE OF SECONDARY SEXUAL CHARACTERS—THE PEACOCK

entrance to the nest, and through this opening she thrusts the end of her bill, and is fed by the devoted male. The hoopoe hen, too, is fed by the male during the nesting period, but no one with any regard for his nose will investigate the interior of the nest of either of these birds. The hoopoe is a beauty which occasionally visits England, but its true range is Central and Southern Europe, Africa, and temperate and tropical Asia.

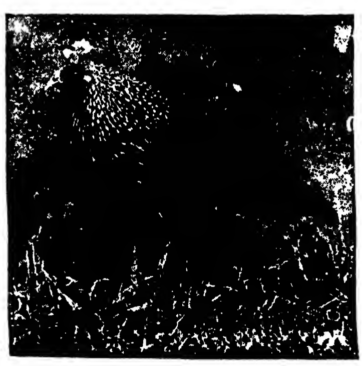
The examples of brilliant plumage may be fitly rounded off by a glance at the game-birds, which include some of the most notable instances of bird adornment, as well as of the grotesque in Nature. In this order we have the grouse tribe, the pheasant tribe, these latter running to over fifty genera the megapodes and brush-turkeys, the curassows and guans, the hoatzin and the bustard quails. The pheasant tribe is especially comprehensive, its genera embracing the partridges, the quails, the jungle-fowl, the pea-fowl, the guinea-fowl, and the turkey, in addition, of course, to all the pheasants themselves. The grouse tribe is broken up into some half-score of genera, in which we find ptarmigan and grouse, blackcock and capercaillie, American grouse, the sharp-winged, the dusky, the sage, the sharp-tailed, the ruffed grouse, as well as the prairie hen and the hazel-hen.

The ptarmigan is notable from the fact that it is one of the birds to undergo three distinct moults in the course of the year. Where the climate is sharply marked off—spring from summer, summer from autumn, and autumn from winter—the costume of the bird varies as distinctly; but in the case of a mild winter the almost pure white of the plumage may be modified by the presence of darker feathers, whereas in northern latitudes, where the summer is short, the full summer dress may not have time completely to mature.

The red grouse, which is peculiar to the British Isles, also undergoes this triple change under conditions already defined, varying between deep black, a rufous chestnut, and a white-spotted phase. This bird is so thorough-going in its changes that it sheds even the sheaths of its toes during the main moult. The blackcock,

CRESTED GUINEA-FOWL

CURASSOW



GREY JUNGLE-FOWL

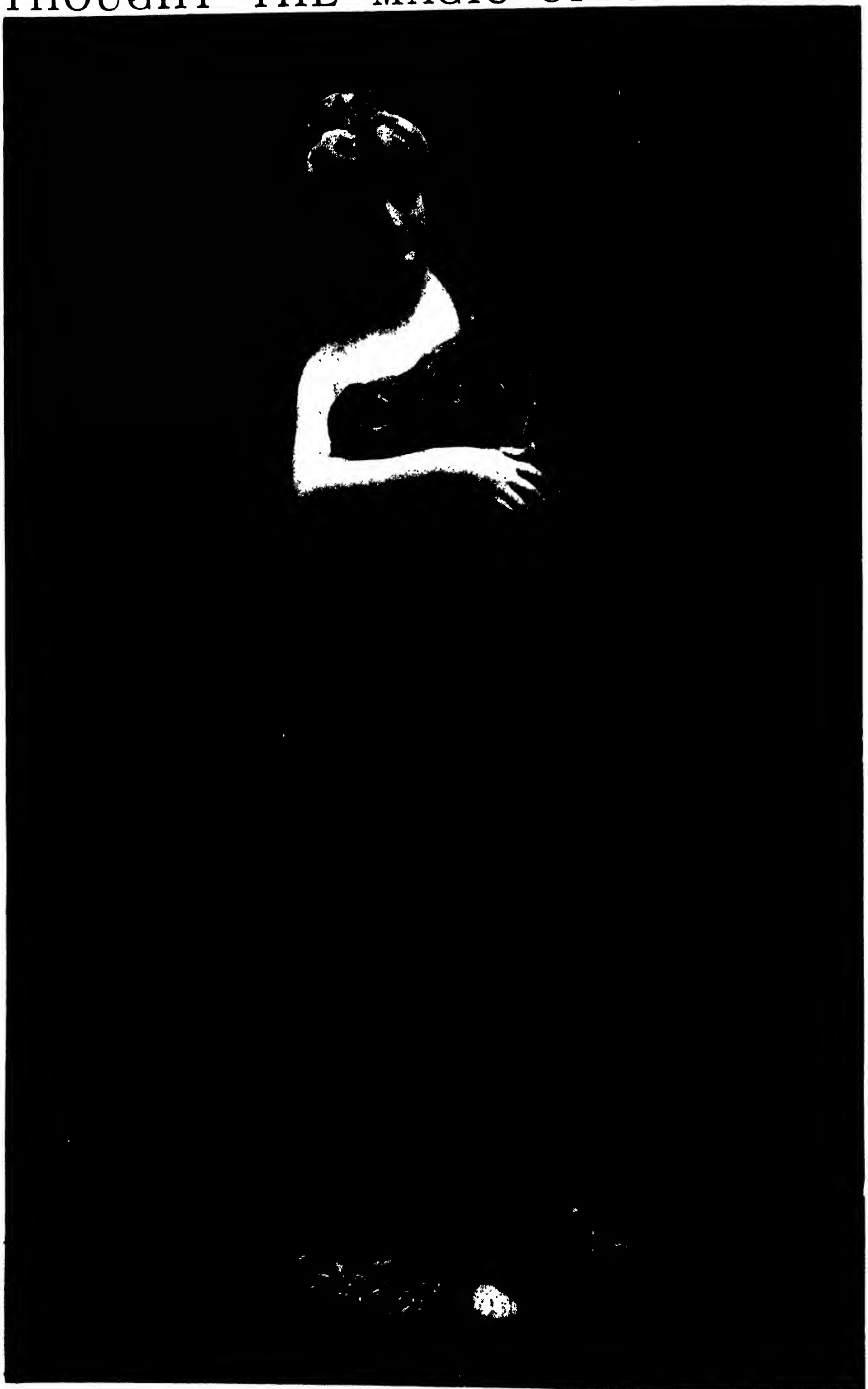
or black grouse, whose mate is known as the grey hen, is famous for his displays in the presence of the hens, of whom he is lord of several, while also paying court to any female capercaillie whose affections are not already engaged. The capercaillie is a larger bird than the blackcock, and, though now found in several parts of Scotland, is a reintroduction, the original stock having been exterminated towards the close of the eighteenth century.

The red-legged partridge is another introduction, and has thriven with us despite unworthy attempts on the part of game-preservers to stamp it out on the score that it is too wary and wise tamely to come up to be shot by the man who follows a dog across its haunts. The grey partridge is a native, and is one of the few birds which thrive with the advance of agriculture. The better a country is cultivated, the more food for the handsome partridge. These two species are easily distinguishable from the fact, apart from other differences, that the grey partridge bears upon the lower part of its breast a dark chestnut patch in the shape of a horseshoe.

Among the various races of pheasants are to be found supremely lovely birds. The golden pheasant is without exception the handsomest bird of its type known in Europe. It is an Asian bird, of course, but is acclimatised in many places. This was undoubtedly the phœnix of the ancients. The Amherst pheasant, the silver pheasant, the tragopans or horned pheasants, the monals, the fire-backed pheasants, are also to be listed with the world's handsomest birds. The typical pheasant known in England is a native of South-Eastern Europe and Asia Minor, and has been acclimatised since pre-Conquest days. It is a bird upon which, despite its elegance, the Nature-lover cannot look with special favour. It remains a pampered alien, nurtured under artificial conditions, only to be shot in swarms by lazy sportsmen at the end of a season, during which it has been hand-reared and rendered tame as the domestic fowl. To preserve this bird for the annual day or so of slaughter, conditions are imposed upon a country-side such as seriously embitter relations between landlord and tenant, more especially between tenant proper and shooting tenant, for whom practically all our farmers have the profoundest dislike. For the preservation of the young of this alien, destined to figure in some annual orgy of slaughter, all our most interesting birds of prey are slaughtered, and the remnants of our carnivorous fauna are brought to the verge of extirpation.

THE GOLDEN PHEASANT, WHICH IS IDENTIFIED AS THE PHŒNIX OF THE ANCIENTS

THOUGHT—THE MAGIC OF THE MIND



THE MARBLE STATUE ENTITLED "LA PENSÉE," BY THE SCULPTOR DENYS PIERRE PUECH

THE BEGINNING OF THOUGHT

Man's Growth as a Thinker Through His Superior Brain - Facility for the Association of Ideas

THE PUTTING OF TWO AND TWO TOGETHER

We have found, on comparing the human cortex cerebri with those of the nearest mammals, that its very much greater size depends, in only relatively small degree, upon the enlargement of those areas to which we can assign definite functions. The greater part of the enlargement is due to the separation of these areas by large portions of the cortex to which we can assign no special function, but which must surely be of high importance, since they, above all, distinguish the human cortex from its inferiors. On microscopic examination of these areas and their connections we find very definite evidence. The nerve fibres which proceed from them do not run to the spinal cord, on their way to some relation with the body, nor do they go to the cranial nerves, which control the movements of the eyeballs and so forth. They go to other parts of the cortex itself, and there they end. As for the nerves which come to these areas and end around their cells, they are found to come from other brain areas.

In a word, these are clearly association areas. They connect all parts of the brain with all other parts. They have no other function, and they are called the "silent" areas, because they yield no reply on stimulation, but their function is, in some ways, the highest and newest of all. This does not mean, of course, that no animal has association areas, or is incapable of the process of putting "two and two together," which we are about to study. But the most characteristic fact of the human brain, in respect of function, is just its unique development of the faculty of putting two and two together, which we shall see to be practically equivalent to what we call thinking. We thus have what appears to be a thoroughly satisfactory correspondence between a special characteristic of structure and a special characteristic of function.

The reader will be tempted, as we have all been tempted, to assume that these do really account for each other, and that the process of thinking does just consist of the sending of impulses through the systems of association fibres from one part of the cortex to another. No doubt that is involved, but close examination of this idea will show that it is much too simple. When we look at the processes of, say, mathematical reasoning, we really cannot get them to correspond to our picture of the brain, with its association areas and systems of fibres. Still, their unique development in the human brain remains, and we may be sure that it somehow plays an important part in thinking.

A better and deeper interpretation of these association areas is now available. Examination of them and their fibres at early ages shows that they are very late in development—which corresponds, of course, to the fact that they occur last in the history of the evolution of the brain. No doubt their function must be very high, and specially human. We find, further, that there is an element of modifiability, inconstancy, almost "fluidity," in the structural arrangement of these parts, contrasting with the rigid, constant structure of lower and older parts of the brain, which are laid down in a fixed fashion, practically identical in all individuals, long before birth. Now, there can be no doubt as to the great human characteristic which corresponds to these facts. It is the power to learn. This is sometimes called educability, as by Sir Ray Lankester, sometimes docility, but it is, at any rate, that great characteristic of man in virtue of which he learns by experience, and so adapts his behaviour, to a degree which

is without parallel in the animal world, and which essentially accounts for his dominance in the scale of Nature.

Sir Ray Lankester introduced this term "educability," in 1899, and, though it is clumsy, it is expressive. In his Romanes Lecture, a few years later, he returned to the subject, asking to what the increased bulk of the brain in man, and to a much less degree in the latest forms of various other mammals, was due. The smaller, older brain is perfectly efficient; its possessors "carry on a complex and effective life of relation with their surroundings.

The True Significance of the Increased Bulk of the Human Brain

"It appears that the increased bulk of cerebral substance means increased 'educability' an increased power of storing up individual experience -which tends to take the place of the inherited mechanism with which it is often in antagonism. The power of profiting by individual experience in fact, educability -must in conditions of close competition be, when other conditions are equal, an immense advantage to its possessor. . . . It is obvious that the opportunity for those individuals with the most 'educable' brains to defeat their competitors would arise. No marked improvement in the instrument being possible, the reward, the triumph, the survival, would fall to those who possessed most skill in the use of the instrument. And in successive generations the bigger and more educable brains would survive and mate, and thus bigger and bigger brains be produced. . . . The result is that the creature called Man emerged with an educable brain of some five or six times the bulk (in proportion to his size and weight) of that of any other surviving brain."

The Newer Association Areas of the Brain the Parts that make Men Educable

Such is Sir Ray Lankester's account. The recent psychologists are in agreement with him, and teach us to regard the association areas as essentially the organs by which man learns. Here, for example, is a recent statement: "There is present at birth a vast number of nervous elements which become only gradually organised, modifying and combining the congenital systems in extremely complex systems which constitute acquired dispositions to modes of action peculiar to the individual. The number of the elements of this nature is so great that the areas of the cortex of the cerebrum in which they predominate, those which surround the various sensory areas and are known as the association areas, are considerably more extensive than the sensory areas, which in the higher animals make up the greater part of the cortex. The greater relative size of the brain of man is chiefly due to the development of these parts. The very great capacity for learning by experience, rendered possible by this vast mass of nervous elements not congenitally organised, distinguishes the mind of man, and raises it immeasurably above that of the highest animals."

Of course, very special attention has been directed by anatomists and students of development to these areas and systems upon which the supremacy of the human brain, and therefore of man, depends. Some of them, for instance, which are closely associated with voluntary movement, and its "educability," can be shown to be much smaller in apes than in men, still smaller in the dog, scarcely visible in the rabbit, and entirely absent in the lower vertebrates. The reader will remember Bergson's demonstration of the *unlimited* character of the human brain, which can make new instruments for Life, and is not confined to those which the body of man itself comprises. Here we see the anatomical structure which corresponds to this power of the human brain.

The Association Areas of the Brain not Fully Laid Down Till Adolescence

It has already been mentioned that these parts of the brain are late in development. This question has been specially studied by a famous German embryologist, Professor Flechsig. Most nerve fibres run in a white sheath of what is perhaps an insulating material, which keeps the current in its place. However that may be, we are sure that nerve fibres which are destined to have this sheath, or "medulla," do not perform their functions until its appearance. In the brain of an infant very many fibres are already properly medullated, and can do their work, or of course the infant could not live. But many are not. Study along these lines helps us to distinguish various tracts in the brain, and to define their order of development; indeed, we owe most of our knowledge of the association systems to Prof. Flechsig and this method. He has shown us that, at birth, the association system is very imperfectly developed, and that some parts are actually not laid down in working order until after adolescence. They are thus last to come, alike in the

history of the race and of the individual. Their non-development is probably responsible in large degree for the non-educability of the feeble-minded and other defective types of brain. Their owners can only learn to a very limited extent, and remain children, or lower, all their days, so far as mental capacity is concerned.

So much for the anatomists. Let us now look more closely at the psychical side of this question. The anatomists can help us no further; what we now require is introspection and observation of the mental processes of ourselves and others.

The Discovery by Hobbes of the Law of Association of Ideas

Here our study goes back, far before modern knowledge of the brain, to the celebrated English thinker Hobbes, who first clearly discovered and laid down the law of the "association of ideas," as it is called. We shall see, on consideration, that docility or "educability," the power to learn by experience, does, in fact, mean the power of forming associations in mind and brain, and retaining them. Thinking, from its lowest to its highest forms, is relating · "putting two and two together," forming associations which guide us in the future. The theory of the association of ideas thus constitutes one of the foundations of psychology. First stated by Hobbes, then restated by Locke, and again discussed by John Stuart Mill and many others in this country, the association of ideas has given its name to what is often called the "Associationist," or English, school of psychology.

In its simpler forms the association of ideas is obvious, though, indeed, the word "ideas" is rather too limited to use. We associate not merely ideas but all manner of sensory experiences, simple and complex. Thanks to memory, these associations in large degree persist, so that our conduct is modified thereafter.

Association of Ideas as Seen in the Conduct of Intelligent Animals

We have all observed and commented upon the association of ideas, so-called, in intelligent animals. A dog has been ill-treated by a man in uniform when it was a puppy, and it hates and fears all men in uniform ever after. This is the essence of thinking, associating, relating, learning by experience; and the greatest successes of the human mind depend upon one and the same process. Indeed, if you know what are a man's associations with a random assortment of things, a star, a name, a book, a tune, you begin to know the very man. This is how we are able to judge of one another by our talk, for our talk betrays our associations with whatever topic turns up; and according as one and the same topic suggests different comments and "trains of thought" to different men, so largely can you know those men, their history, their interests and purposes.

We are very liable to think of the association of ideas in purely mechanical terms, as is almost inevitable when we observe how prone we are to form associations between things which merely happen to be seen at the same time, though there is no other relation between them. But this purely mechanical view of the association of ideas is quite inadequate. Like the whole of our mental processes, which the nineteenth century used to interpret as a kind of photographic or cinematographic succession, wherein the mind merely played the part of a passive plate, the association of ideas, from its lowest to its highest, includes a volitional element, an element due to the vital interests, concerns, intentions, desires, of the individual in question. Otherwise, we should all derive similar associations from similar experiences, and should retain them similarly: but nothing could be further from the truth.

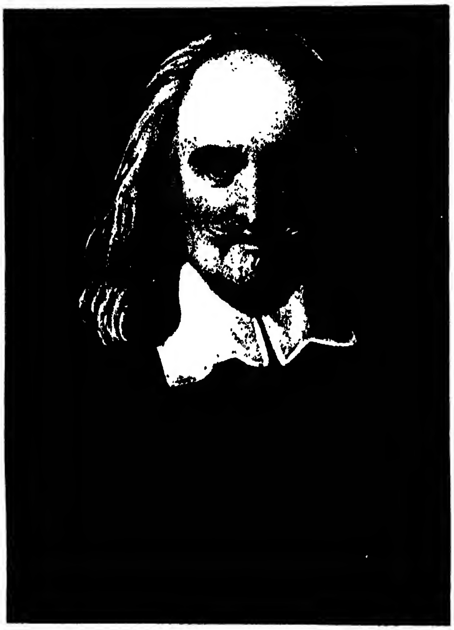
The Influence of Our Own Wills and Interests on Association of Ideas

The so-called laws of association are no doubt mechanically true in part, but they do not express the whole truth. What you see, and what you associate, mightily depend on what you are looking for. It is not true that the "laws of association" drive us about from pillar to post as if *we* counted for nothing. On the contrary, we each go our own way from similar beginnings, partly because our minds are already stored with different associations, but far more because each of us has his own interests, and thinks accordingly. If we are mad, or have an obsession, we drag "King Charles's head" into everything, where other people would see no connection, but, short of that, our tendencies are just the same. We wish for something for ourselves, or we hold a belief, in some religion, in money, in evolution, in some scientific theory, in Socialism, or what not; and this belief determines the character of our associations and our thinking in general.

How will this affect *me*, or someone I love, or my church, or my belief, or my enemy, or the unborn? These are the questions

always asked respectively, by various kinds of people, according to what they are; and though they all form associations of ideas on similar lines, they use those lines, each in his peculiar way, for his own peculiar ends.

Another criticism to be passed on the purely mechanical theory of association is that it takes too little account of the motive force which drives the chain of associations. Two men may have two very similar brains, may have had very similar experiences, but when you place them in similar circumstances, and expect them both to reach similar conclusions, you are disappointed. The fact is that one of them reaches no conclusions. The chain does not run. If, for some special reason—say, money, or ambition, or self-protection—he were really to be started "thinking on those lines," as we say, he would reach the expected conclusion, but, as a matter of fact, the process stops for lack of motive. The truth is that, as Locke said, the greater part of mankind think very little and very seldom. If they are hungry and notice the smell of food, they think of dinner; and throughout the day they achieve various similar associations, but little more. Beyond a certain humble stage, in which many animals may share, as in the case of dinner, we really require some special interest or motive to keep our association sequences going.


THOMAS HOBBES

The notion that it is purely mechanical and automatic, so that you put in a certain idea or sensation, and then the wheels begin to go round, is mythical. Every propagandist knows better. The trouble is to get people to think. The machinery is there, and the appropriate start can be made, but nothing happens, because the living will, the purpose, the *élan vital* of the individual, has not been engaged; and after a stage or two the process simply stops for lack of motive. Undoubtedly there is a mechanical element in thinking, which we cannot unjustly represent in terms of the association of ideas, and in pictures of association fibres connecting eye and ear, and so forth, but we go very far wrong if we suppose that this machine will work without power being put into it. That power is the vital intention of the individual, and it is a *sine quâ non*. It may be adventitiously aroused, as when a boy studies a subject for a prize, or a politician advocates and "gets up" a subject of another kind for a prize of another kind, and afterwards they never think of the thing again. Or it may be *organic*, whether sane or mad, unselfish or selfish, trivial or momentous; and then the mind of the individual will work along these lines always, not as a ball rebounds from successive cushions of a billiard-table, but as a man goes from point to point because he means to get somewhere. This is really a very profound question, because it involves our understanding of the different types of minds and of men.

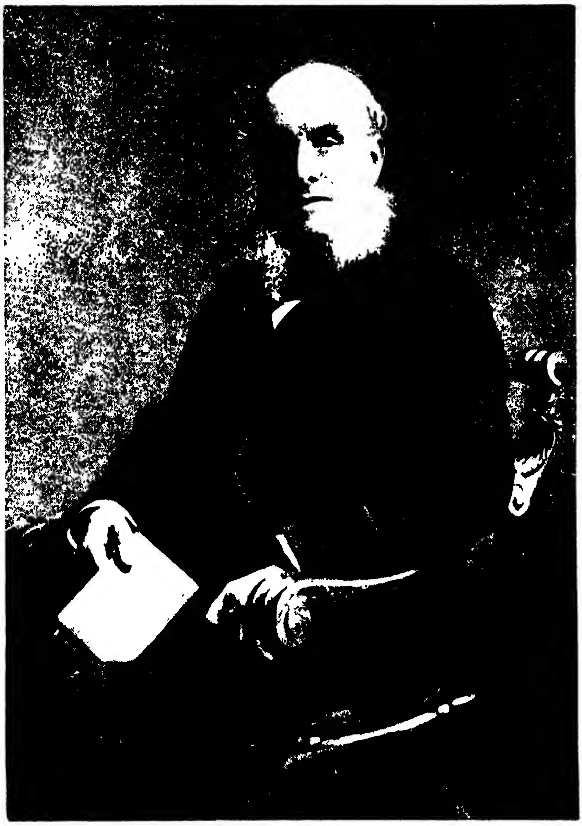
We recognise one man as a "great thinker," and another as nobody in particular. Perhaps we assume that the first man was necessarily more highly endowed with association fibres, and so forth, than the second. He had a different kind of brain, which enabled him to do these feats. In part, of course, this may be true, but it is certainly not the whole truth.

Examine the work of one of these great thinkers, and you may find that the taking of any given step, the forming of any given association, was not in itself an exceptional feat. Any of us could have done it—if we had "had the mind," in one sense of that phrase. The second of our two men may have been much more richly endowed than the first, he may have had more opportunities, and the "laws of association" should have done the rest. But, in fact, nothing happened. There was no motive; he did not care; other things attracted him. The man we call the great thinker really had no better a machine, *but he chose to use it.* This view, which is in harmony with general experience, consorts with the view of

association which we have just laid down. It gives us the truth that character, the vital drive of a man, the direction of himself, is the most important fact about him. Of course, the machinery is important also, but we must no longer try to interpret the man and his processes solely in terms of his machinery.

In a letter to his cousin Sir Francis Galton, Charles Darwin wrote, on this very question: "I have always maintained that, excepting fools, men did not differ much in intellect, only in zeal and hard work; and I still think this is an *eminently* important difference." We are here discussing the physical and psychical basis of what we call intelligence or the intellect, and Darwin's verdict doubtless stands, in large measure. Exceptions there are, both in the case of certain individuals and in the case of special kinds of intellect, like that associated with mathematics. But the word "zeal," which Darwin uses, counts for far more than difference in intellect, when we compare the greater number of men with one another. Unfortunately, while it is easy to lay down semi-mechanical laws of association, and even to show how the structure of the brain seems to correspond to them, when we come to "zeal," "interest," the motive power which is present in one man, so that he uses his machine, but absent in another, so that he does not, we pass beyond the limits of knowledge and of material evidence altogether.

Meanwhile the laws and conditions of association, for what they are worth, must certainly be studied. If we consider our own minds we recognise at once that they have a sort of acquired structure which depends upon their experience, largely determined by their interests. In virtue of it we think of things together, or in sequence; we have once thought of them, or have perceived them, in some relation, and we can think of them again in the same relation.



PROFESSOR ALEXANDER BAIN Elliott & Fry

Some kind of links—the nature of which we can imagine as we please—have been formed in our minds, and so the "chain of ideas," as we often call it, can be reproduced at will. Anyone can illustrate the association of ideas for himself, and can also discover a very important fact about what we call memory, by simply writing down a string of nouns, fifty or more, in a column, and then reciting them without a flaw, as he certainly could not do if their sequence did not depend upon such links already existing in his mind.

Thus, noun suggests school, school a particular master, his name the name of the place he usually occupied in the cricket-field, cricket Australia, Australia the Empire, the Empire Tariff Reform, Tariff Reform oratory, oratory Demosthenes, and so on as long as you please. But no two people will compose the same sequence, though all start with the idea "noun"; and, on the whole, the character of the sequences to which we incline will depend upon something deeper than the so-called laws of association at all.

It is upon greatly elaborated systems of association of this character that the advertised schemes for assisting the memory are in many cases constructed.

The last great "Associationist," the late

Professor Bain, of Aberdeen, whose famous books, such as "The Senses and the Intellect," go back to the 'fifties of the nineteenth century, always maintained that intellectual or philosophic genius depended upon the number and variety and range and fitness of the associations of ideas. But that in its turn must largely depend, as we have tried to insist, upon deeper factors of the mind.

The Active Part Played by the Mind in Forming Associations

Dr. McDougall has lately written confirming that newer view of association which the Associationists, from Hobbes to Bain, ignored. Here is his comment: "Thus if I have on one occasion seen a cat seated on the back of a pony, I shall be apt to think of that cat whenever I again think of that pony. The static method describes the fact by saying that the idea of the pony is associated with the idea of the cat, and that the one idea, therefore, reproduces or tends to reproduce the other. . . . The most important point to note is that the mind does not play a passive part in the formation of associations. Objects become associated for the mind, not merely because they are presented to the senses simultaneously or in immediate succession, but when and because the mind perceives or otherwise thinks of them as related with one another; and it does this only in so far as it is interested in them as so related, that is to say, in so far as they stir up some conative [willing] tendency. To go back to the instance of the pony and the cat: if, at the moment my glance fell on the two animals, the cat had been seated on the ground at some little distance from the pony, I should have noticed both animals only in the most fleeting fashion, if at all, and I should not have associated them together. But this spatial relation implied a friendliness between them which is unusual, and appeals to my interest in the behaviour of animals; hence, out of all the details of the scene presented to my vision, my mind seizes upon these two objects and their relation.

Contiguity and Similarity as the Two Modes of Mechanical Association

"It may be remarked in passing that this example illustrates the impossibility of describing even so simple a process of association as this in terms of sensation and imagery. The mere spatial relation of the two visual forms is of no interest. It is only because they mean for me far more than is actually presented to the eye that the situation appeals to an interest, and draws my attention."

Given that we realise and accept this truer and deeper view of the association of ideas, there is no harm in our noting the quasi-mechanical laws upon which past psychologists have spent so much study. It used to be said that association of ideas acts in four ways—by contiguity, simultaneity, similarity, and contrast. This fourfold classification may certainly be simplified. Contiguity in space, as when an old tune recalls the surroundings in which it was first heard, and simultaneity or contiguity in time, as when the memory of one occurrence arouses the memory of another that happened on the same day, or during the same holiday—these two are both reducible to the single principle of contiguity, either in space or time. Likewise, similarity and contrast, the one being merely the negation of the other, are reducible to one principle; so that the modes of association are really reduced to two—contiguity and similarity.

The Rich Variety of the Mind in Forming Associations

But these laws or modes of association may work upon all manner of levels. For instance, in conversation a man uses a word which stirs associations in both of his hearers; but whereas in one the association is rational and subtle, beyond psychology to define in mechanical terms, in the other the association is purely sensory and auditory, and leads to the making of a poor pun. The word has suggested another word of similar sound, but no association in meaning. Similarly, in popular catch-words, "king and country," "cocoa and cant," there is an associative element which is purely sensory, and depends upon a similarity of consonantal sound. The virtue of alliteration or "head-rhyme" is thus explained.

But the same is true in poetry, and end-rhyme; and every critic soon learns to detect and appraise the level of association on which the poet's mind was moving. Love, dove; pearl, girl; moon, June; star, afar; ocean, motion—these all require careful observation on the part of the critic, in order to decide how far the merely sensory element in association, as against the rational and imaginative elements, has determined the poet's pen. Everyone who is familiar with the poetry of, say, Swinburne and Wordsworth knows the difference. The two poets each have their definite associative tendencies, certain words and ideas occur, and we may be fairly sure to what they will lead in an ensuing line, but

the plane of association is very different in the two cases.

The way in which a clever man can deliberately play with his "faculty" of association, on all sorts of planes at once, is illustrated in much humorous verse, like that of Hood or Lewis Carroll. This latter author, we may remember, was a distinguished mathematician, and he could at will associate ideas rationally, as in his mathematical treatises, or with a mixture of reason and unreason and mere attention to similarity in sound, as in his immortal works.

The Tendency of Associations to Become Fixed and Sacrosanct

The element of association in language is well illustrated by what are called onomatopœic words—in which, that is to say, the name makes the thing named. Such words are hush, buzz, whirr, writhe, whisper, and a host besides, in all languages. Here there is a rational association. In other instances, the association between the word and the thing is purely arbitrary. But it is constant, and after a time it comes to wear the aspect of being rational and inevitable, the mind supposing the association between sound and sense to be inherent in the nature of things, as in the case of the cricketer who was asked why a particular kind of ball is called a "yorker," and replied: "Why, what else could you call it?"

Early and long-repeated associations tend to become sacrosanct, natural, part of the eternal order of things in this fashion, and when they are broken we are shocked or bewildered beyond measure—as, for instance, at proposals for rational spelling, or at the suggestion to modify a religious ceremonial, which wears for many the aspect of an attack upon religion.

The High Importance of the Relation Between Association and Memory

Thus we carefully observe that, though all thinking is relationing, or the association of ideas, and though the "laws of association" appear to be general and simple enough, yet there are all levels upon which they work, from that of the old lady who thanked the preacher for the reiteration in his sermon of "that blessed word Mesopotamia," up to the mind of Newton, which leapt from a falling apple to a falling moon, or a Wordsworth's, who said that Milton's "soul was like a star, and dwelt apart."

The association of ideas cannot be left without reference to its high importance in relation to memory. Here we speak, of course, not of sheer memory, which is retention pure and simple, but of the reproduction, the accessibility, of what is retained. It is argued by many psychologists that the purely retention-factor in memory is unmodifiable in each individual, by any means. It appears gradually to decline with advancing years, and is never keener than in the "teens." But far more important is the power to use and to connect what one knows. This depends upon association. The great thing is to have as many hooks as possible with which one can fish up a fact or an idea, or any other memory, from the depths of the subconscious. This is achieved by thinking over what one learns, for thinking is associating, relating, and means that new connections are being formed with the memory in question, in virtue of which it will become proportionately more accessible and available in the future. The proper study of association and of memory will lead some day to very wide and radical revision of many of our ideas and methods of education.

Associations that Resound Curiously Through the Senses and Link them Together

A word may be added regarding what is called the "association of sensations." This is a psychological abnormality, though not to be called morbid. Its subject hears trombones, perhaps, and has an associated sensation of crimson. Certain vowel-sounds may have definite colour-sensations associated with them. Cases are recorded where colours evoke sensations of hearing, where hallucinations of smell and of taste are aroused by colour and sound, and *vice versâ*, but by far the commonest are those of visual sensation aroused by sound.

It is probable that such musicians as Wagner, and doubtless many poets—"I *see* the crimson blaring of their shawms"—have been the subjects of association of sensations, but the most numerous instances are recorded among the insane. The cases are striking, because they correspond so well to Hume's theory of the physical mechanism of association—that when any given nerve cell is excited an impulse passes along the nerve fibres which connect that nerve cell with some other, and cause it to yield up its idea, as a bell yields up its note when it is struck. Thus the visual cells are aroused by impulses from auditory cells in action, and yield their specific psychical function, which is vision, according to the law of Müller. Of course, such a theory is hopelessly inadequate when we come to deal with the association of real ideas, but it seems to explain these cases of the association of sensations fairly well.

SAFEGUARDING THE FOOD OF THE CHILD

In this steam steriliser, used by the Battersea Borough Council, the milk is put in stoppered bottles packed in wire baskets, and is kept at boiling point in the steriliser for twenty minutes

THE ONE NATURAL FOOD

The National Need for an Ample and Safeguarded Supply of Pure Milk

A LIQUID WITH SOLID NOURISHMENT

At last we approach the age-long controversies on diet, which interest all of us, and which, indeed, are far too interesting to many people, who would do better to think of them less. Hippocrates himself, the Father of Medicine, sought to regulate the diet of his patients, and no good physician of today proceeds to any medicinal considerations until he has first regulated his patient's food. But the whole subject is one of volumes, and unfortunately on many cardinal matters we are still in doubt. Probably no one yet, for instance, is entitled to a conclusive opinion, either one way or the other, on the vegetarian controversy. It is well, therefore, that we should begin by dealing with matters of the first importance which are not in dispute, especially since they will help us when we proceed.

Here it is surely logical to begin with the unique substance which Nature designed to be food, and to learn all we can from the natural indications. In one of the recent Irish plays, an old woman, asked whether she will have water in her whisky, says she will have it "as God made it." The principle is a good one, though the application is surprising, and we may do well to follow it. None of our foods but milk alone—or, to be more precise, human milk during the first year or two of life—can claim to be made for the purpose. The rest are living creatures, or their products, which do not exist for us, but which we take and use. Each of them requires to be discussed on its merits, for it has no natural hall-mark as a food for man. This applies equally to muscle or to wheat, and helps neither side in the vegetarian controversy.

As regards the adult, we are left to our own observation, experience, and appetites. Nothing in Nature has been provided for him, notwithstanding the assumptions of the old theology, which thought that the whole of the rest of the living world had been made for man. But long ages of evolution, acting on whatever lines our theories may imagine, have yielded the order of Mammalia, of which the mothers suckle their young. At the head of the mammalia we stand, with every evidence that Nature made no mistake in evolving them; and when we study the milk of any of the mammalia we may be absolutely certain that we have a natural object-lesson as to the best diet for the young of that species.

Cows' milk, of course, only tells us what is perfect for the calf, not what is perfect for the baby. But all the varieties of milk agree in the main, and they have much to teach us. So special is the place of this food that man everywhere has sought to use the milk of other mammalia for his own purposes long after infancy; and milk is everywhere made available for various fermented products, for cream, butter, and cheese. We have only to consider these substances, and their place in the ordinary dietary, in order to realise that man largely relies upon the milk of other mammalia for his own nourishment; and the significant fact has to be added that, in states of ill-health or positive disease, he always finds it advantageous, or necessary, more and more to fall back upon milk and its products.

No doubt the public is tired of hearing the praise of a food which is insipid. It is natural enough that milk should not appeal to us who scour the ends of the earth for innutritious condiments wherewith to season our food. Having thus debased the appetite, we find it hard to credit the virtues of a food which makes no appeal to the vitiated palate at all. How much wiser and more valuable was the appetite of any of us when he or she was but twenty-four hours old! Did we then complain that milk was

insipid? On the contrary, the slightest hint of a foreign flavouring matter in milk—due, for instance, to the medicinal use of some essential oil by the nursing mother—may be sufficient to make a wise child refuse the breast. Therefore, until at last we learn that hunger or appetite should be an organic demand arising primarily in the state of the blood, and not a desire for palatal irritation, we shall most of us be prejudiced against the ideal food which Nature has provided, and on which she has reared mankind, but to which she has chosen in her wisdom to add no condiments.

The Reason why Milk Does Not Agree with Some of Us

A second objection to milk depends upon the fact that, when many of us try to swallow, neat, a tumblerful of cows' milk, it upsets us. But that is not surprising. Cows' milk was made for the stomach of the calf, which is very different from that of man. We require, in many cases, to allow for the difference, and dilute cows' milk, or take it in small quantities at a time, so that it may form light clots in the stomach, which are easily digested, instead of a dense and large clot which the human stomach is not particularly well fitted to deal with.

A third more or less conscious objection to accepting the physiologists' praise of milk is based on the fact that it is fluid. The doctor asks his patient: "Well, what food have you had today?" "Nothing at all," replies the patient or friend. "What! no milk?" "Oh yes, I have had some milk," is the reply. Such a conversation may be heard in almost any sick-room. The nurse has persuaded the patient to take some milk, but of course that does not count.

The Absurdity of Thinking that Liquid Cannot be Nourishing, though All Nourishment is Liquid

Of all the quaint notions to obtain among a species of mammalia this is surely the quaintest. It might have some vogue among the birds or reptiles; but who can explain its prevalence among an order of beings distinguished by, and necessarily dependent for its amazing success upon, the production and use of milk? It really seems that, to some extent, the public judges by the physical state of a food. We speak of "solid nourishment." If, therefore, a thing be liquid—always excepting "glorious beer"—it is not to be taken seriously. Thus the presumption is in favour of cabbage as against milk. But this style of judgment, as expressed in the absurd phrase "solid nourishment," is worth nothing at all. On entering the stomach, the solid matter which abounds in milk is precipitated or curdled; and, on the other hand, all food whatsoever, if it is to be absorbed, must finally take a liquid form. The process of digestion is, among other things, a process of liquefaction. At the last moment (and why not at the first?) all nourishment must be *liquid* nourishment.

Yet other liquids, curiously enough, have only to be advertised for the public to credit them with amazing virtues. Liquid preparations of the muscle of the ox are believed in, though they are not "solid nourishment," presumably on the ground that at least they are derived from a solid substance. Powdered milk, a very useful thing in its way, would presumably win acceptance at first sight everywhere, and indeed it is useful in educating the public to the fact that there is "solid nourishment" in milk. But all this acceptance of solidity as a criterion of nutritive power requires to be exploded.

Strange Popular Ignorance About the Value of Solid Nourishment

The invalid who is dying for need of nourishment is not offered milk, but some wretched soup or jelly, the basis of which is the peculiarly innutritious substance called gelatin. When reproached, the attendant remarks that surely the soup or jelly must be splendid stuff, for, lo and behold, it will set when cold! So also will water when it is cool enough. Yet because milk will not set when cool, and jelly will, the latter is supposed to offer more "solid nourishment"! We must certainly have done with such methods of reckoning; and we may note in passing that jelly, the basis of which is gelatin, and which used to be so very popular with invalids and doctors, is put out of court in modern invalid dietetics. It is very easy to take, but it is not worth taking. The gelatin, though allied to the true proteins, is not one, and cannot take their place, and the rest is merely water.

The presumption in favour of milk—including its products—as a food of unique importance for the human species is increased when we learn that the human infant is longer dependent upon it than the young of any other mammal. Infants may doubtless survive who have never tasted human milk, but some other must be substituted. No human being ever survived without the indispensable aid of milk. No milk, no man. The unfortunate fact is that this substance, which suits us so well, is also an admirable diet for many microbes, some

of them very dangerous. Thus, while pure milk is the best food, and while no man can be produced without milk, impure milk is one one of the deadliest things in the world. Milk thus touches both extremes. On all counts it may be said that a due supply of good milk is cardinal for the health and maintenance of any community, but that impure milk is almost the most deadly thing that any modern community permits.

The Dangerous Inattention of the Public to the Impurity of Milk

Thus we want some sense of proportion in our treatment of three typical fluids—water, beer, and milk. As to safeguarding the water supply, almost everyone is well enough informed. The dangers inherent in ordinary urban drinking-water in this country—say, in London—are too often exaggerated by those who figure strange forms of life, apparently a variety of aerial insects, in drinking water—forms which probably explain the popular notion that microbes have legs and wings. Yet, for practical purposes in this country, we need fear water only in relation to typhoid fever, and that only when someone has been criminally careless. Except in actual epidemics of typhoid fever, there is little need for us to worry about drinking-water. True, lead-poisoning may sometimes occur through water, but such cases never, or hardly ever, happen under modern conditions.

The purity of beer and whisky is also much discussed. A Pure Beer Bill used to come regularly before the House of Commons, and a Royal Commission lately sat on the subject of whisky. We still pay far more attention to the purity of beer and of whisky—which, when absolutely pure, slay millions—than to the purity of milk, which, when impure, slays millions, and, when pure, is the only perfect food—the only food the only function and purpose of which is to be a food.

The Deadly Character of the Best of Foods When It is Impure

In a vague way, we do realise that there is something other than water in milk, even though it is not "solid nourishment," for we object to the addition of water to milk. Provided that no water has been added, we call the milk pure. It may be swarming with the microbes of tubercle, infant diarrhœa, and so on; it may be richly contaminated with cow-dung and hairs, but so long as the dairyman has not added water to it, nor taken cream from it, we call it pure milk. Yet the dilution of milk with water is the least injury it can suffer. Ten per cent. of samples of milk examined in London today contain living and virulent tubercle bacilli. Thus, when next the reader hears talk about the purity of water, or prattle of commercial origin as to "What is Whisky?" let him ascertain whether the speaker has any sense of proportion, and knows what infected milk accomplishes in civilisation today. Meanwhile, if he has children in his own house, and is unacquainted with the history of the milk which is supplied to them, let him thank himself for trouble, say, in the glands of the neck, if not for much worse.

In this section we are concerned with the health of children, as well as of adults; and it may certainly be acknowledged that, in regard to milk, the child is the more vulnerable of the two. The evidence obtained by the Royal Commission on Tuberculosis led to the view that the hydrochloric acid in the gastric juice of the adult probably destroys most, if not all, of the tubercle bacilli which he is almost constantly swallowing in his milk.

The Need for Boiling or Pasteurising All Milk Taken by Children

But children are not so well protected in this respect. Both as regards tubercle and other diseases, the child's stomach is far less likely to protect it. Probably we are right in saying that unboiled milk should not be allowed to any children, except in the very few cases where the farm is conducted on definite hygienic principles, with regular testing of the cows, model sheds, immediate cooling of the milk, and all the other precautions—which are taken by some two or three farms alone in this country.

The whole of the problems raised by milk cannot be discussed here, because they involve the special problem—huge in itself—of tuberculosis, which is dealt with elsewhere as a whole. But it is certain that the verdict of science is unequivocal today in demanding some such standard for the national supply of milk as is promised in the Pure Milk Bill, much talked about, and sometimes even introduced, by the Local Government Board, but kept well under control by what is called the "agricultural interest." This is a national matter, which concerns all of us. The last thing we can afford to do is to ruin the farmer, who gives us our milk supply. If the problem were seen as science sees it, and with any idea of the gigantic annual cost, in a host of ways, of the diseases spread by impure milk, there would be little difficulty in framing a law which

should not injure any but the grossly and criminally careless farmer, if such a person exists. Meanwhile hygienic science gives clear indications of his duty to every householder, responsible for children, who will listen. The milk need not be boiled, for it may be pasteurised, and its taste is then less altered.

The recent evidence is clear that milk is changed chemically by even the less severe of these processes. Probably this change, which is of a very obscure character, depreciates the value of the milk as a *sole* food for infancy. So much may be granted, though, indeed, the supposed danger of "infantile scurvy" can easily be remedied by the occasional or daily addition of a little orange juice to the milk. But where the milk is only part of the diet, and the child or adult is also getting a variety of other things, including fresh fruit and vegetables, there is no danger in sterilising the milk, and many dangers of the gravest kind are thus averted. Until the time comes when we have a pure milk supply, it is to be looked upon as something very like a crime in the eyes of science to give unsterilised milk to any child.

The Wisdom of the Japanese in Making Milk a Staple of the National Diet

But milk is not merely a food for children. That which enables the babe and suckling to live, to grow, to develop, is certainly able to maintain the adult. Cows' milk would not do as the sole diet of the adult, for it is too watery, and is also said not to contain enough iron for his purposes. (It need hardly be said that milk does contain iron.) Though milk be a food for babes, it will give quite as much strength as meat to a grown man. It is milk, despised by the strong man when his need is least, that will save him in illness when his need is greatest, and when, as might be supposed, it should prove itself more inadequate than ever. The scientific evidence on this subject has lately made a great impression on the Japanese, whose land is very poor in domestic animals, the cow included. The powers that be in Japan, having become aware of the value of milk, not least in relation to the development of the skeleton —and the Japanese are sensitive about their small stature—are purposely trying to make it a staple of the national diet. It is to be wished that we could learn from our allies, who have thus tried to profit by the scientific demonstration of the value of sugar and of milk, which are just as valuable for us as for them. It is certainly safe to say that the use of milk and its various preparations—such as powdered milk, the various tonic foods of which milk is the basis, dairy products, and sour milk—will steadily increase among civilised peoples, just in proportion as the present excessive use of meat among many of them will decline.

The Need for Breeding a Strain of Good Milking Cows

The problem of the cost is formidable, and will become more so. It has to be faced. Already the cost of milk is a most serious affair in all but well-to-do families. It will rise, instead of falling. The inevitable result of the precautions which will shortly have to be taken in order to make the milk supply safe will be an increase in its retail cost. The milk now supplied by one or two "ideal" farms costs about twice as much as ordinary milk; and no one who has paid a visit to such a farm can be surprised. There are, however, two ways in which the cost of milk may some day be reduced. We require to apply science to this as to other problems. We then learn that the capacity to yield a copious supply of good milk is largely native in the cow, and is transmissible to its offspring. A good milking strain is thus a thing to be recognised and bred from. At present the chief immediate application of genetics for utilitarian purposes to the mammalia is Major Hurst's new work upon horses, from which he hopes to be able to produce valuable types combining many good points, but, above all, speed. How much more important good cows' milk is than speedy racehorses, to every individual and to the nation, can scarcely be estimated; but the time will come when the problem of the inheritance of milking strains is dealt with on genetic lines, and the results may confidently be awaited, though the subject has not yet been studied with sufficient knowledge.

The Diet and Health of Cows in Relation to Milk-Giving

Secondly, far more attention than hitherto must be paid to the nurture, and especially to the diet, of the milch cow. Tuberculosis in cows really pays nobody, not even the farmer who avoids the expense which might have averted it. Unfortunately, too little attention has been paid to the question of infection among cows. We do not really know how the tubercle bacillus reaches the cow, and so the cow's udder. But this is a problem which a special departmental inquiry could probably solve without much difficulty. As for the cow's diet, much

good work has lately been done on that subject, but the number of farmers who apply the valuable knowledge gained is negligible. The present year marks the first appearance of Agriculture as a full section at the annual meetings of the British Association; and if that means that some day the Board of Agriculture becomes what it should be, part of the milk question will be nearer solution. In this particular we have the knowledge, but it is not employed; and cows are too frequently fed on brewers' grains and other things which are supposed to enrich the milk in cream, but really add to it only indigestible, oily material, which the cow's blood has no use for, and therefore gets rid of. This helps to make work for the children's doctors, but has no other known advantage.

The reader must be patient if he argues that we are wandering too far from personal hygiene. The quality of the milk one drinks most intimately concerns one's personal hygiene; and that quality depends upon a host of factors, all of which have to be considered.

The Intimate Relationship Between Impure Milk and the Spread of Tuberculosis

You do rightly to prefer that your dairy shall be clean—to object to find, on entering the place, that a large bowl of milk is exposed, without covering, to the air, the dust, the foul feet of flies (which were in stable manure a few seconds earlier): and to insist that milk shall be supplied in properly closed glass bottles. But, in fact, one should begin at the beginning. If, for instance, the cow's udder was tuberculous, no subsequent precautions in mere storage and transit are of any avail.

Milk is a secretion of certain glands of the cow; and if we want good milk we must begin with the cow. We must have the right kind of cow, we must house and feed it properly, and *then* we must take proper care of what it yields us. The beginning of wisdom and of health in this relation is to put brains into our agriculture, from the Government department downwards. But how that is to be done in a country where brains are really not believed in, though none produces better, the present writer cannot say.

The more we learn of the relations between milk and tuberculosis, the more intimate they appear. Milk widely spreads the disease. But it is also probably the best preventive of the disease, assuming the infection to be present. Tuberculosis is largely a disease that depends upon the nutrition of the individual. Every day we find that improvement in terms of nutrition enables a tuberculous patient to conquer the disease. It is a wasting disease, in all its forms; and we are glad when we can increase the patient's weight, which probably means increasing also his resistance. One of the reasons why tuberculosis is mainly a disease of the poor is that the well-to-do are better nourished.

The Enormous Importance of Milk and Butter in Cases of Consumption

Of all forms of nourishment in this relation, milk is the most important. It contains everything the patient requires. Cod-liver oil has a high and well-earned reputation in tuberculosis. When all is said and done, cod-liver oil is simply a familiar oil, widely distributed in Nature, which is obtainable cheaply from the liver of the cod, together with various unpleasing substances which often interfere with its digestion. But milk contains at least as good an oil as anything in the cod's liver, together with many other valuable things, and nothing unpleasant. If cream were as cheap as cod-liver oil, no doctor would ever prescribe the latter. The same is true of butter. Nowadays the doctor who wishes to fatten a patient, especially in relation to actual or threatened tuberculosis, naturally begins with pure milk and its products. If expense does not matter, let the patient have his fill of cream and butter, up to the limits of comfortable digestion, before he need trouble about cod-liver oil. Most patients prefer them.

How Milk Represents Every Substance Necessary in Food

Since milk occupies, on all counts, a unique position among foods, about which we find ourselves involved in so many controversies, we shall do well to observe its composition, which may be a guide to us hereafter. It contains representatives of all the classes of substance which we recognise as desirable, or actually necessary, in a diet. The proportions differ widely in different kinds of milk, according to the structure and digestive capacities of the particular kind of young mammal for whom the milk in question is destined. But all milk contains representatives of the five categories—proteins, fats, carbohydrates, salts, and water. Of these five, as we shall later see, the second and third are not absolutely essential to life, but the other three are. The proteins of milk are two, one called caseinogen (which becomes "casein"), and the other called lact-albumin. It is this latter that becomes clotted and forms a

"skin" when milk is boiled. It is particularly digestible and valuable. It is often called whey-albumin, as it remains in the whey when rennet is added to milk, and it saves the lives of many children who could digest no other form of protein. It is a pity that children should reject it when milk has been boiled, as so many of them do.

Of course, so long as we accept the popular and medical notion that a protein is a protein and no more is to be said, we shall have no idea that these proteins of milk are to be valued, as against other proteins, except in proportion to their quantity. But modern physiological chemistry has taught us that that is a great mistake. Proteins vary very widely in their constitution. A protein molecule is the most complex known to chemistry. It consists of, or comprises, a number of sub-molecules or atomic groups, the nature and respective numbers of which vary in each case. The business of the body is to replace its own characteristic proteins. At a pinch, and with much waste and effort, it can do so from a large number of proteins, both of animal and vegetable origin, but only cannibalism would provide us with what we actually require, ready made.

The Best Selection of Molecules Necessary for Upbuilding the Body Found in Milk

Short of that, the proteins of milk have no rival. Much has yet to be learnt about their internal constitution, but it is already certain that they comprise the best possible selection of sub-molecules from which the body is able to construct, after the processes of digestion in the stomach and bowel, those particular proteins which are characteristic of itself. We see clearly that to take a given quantity of caseinogen or lact-albumin, and a similar quantity of protein from, say, peas, and to assume that they are of equal nutritive value for man, is absurd. The pea-protein will be the best in the world for the pea-embryo, but many times as much of it would be required as of milk-proteins in order to yield the same number of sub-molecules from which human proteins could be constructed by the body.

These recent discoveries compel us to write out all our dietary tables afresh. To say that a man doing ordinary work, and of a certain weight, requires so many grammes of protein daily means nothing, unless we first state what protein. And when we begin thus to distinguish the proteins, as we must, we naturally find that those which Nature provides for the young of any species take the first place for that species at all times.

In a normal dietary fat is included, for purposes which we shall later discuss. Milk comprises such a fat, in a very suitable form for absorption. A fat is best taken in the form of what is called an emulsion, such as cod-liver oil emulsion. This means that the fat is broken up into a vast number of very tiny globules or droplets, each of which retains its independence. In such a form a fat is far more easily digested, because it is more easily accessible to the digestive juices. Milk is a perfect instance of such an emulsion, a fact which largely accounts for the easy digestion and complete absorption of the fat which it contains.

Cream and Butter the Best of All Fats for Human Use

There is a second advantage also. The oils or fats constitute a long chemical series, of which the lower members are fluid at ordinary temperatures and the higher members are solid. Most or all of the oils or fats we know are mixtures of lower or higher members of the series in various proportions. The fat which is best for us is one of which the composition most nearly approaches that of the fat in our own bodies—which is just poised between the fluid and the solid states at the body temperature. Thus judged, different fats vary widely, from such forms as mutton-fat, for instance, to the fat of milk, which is naturally the best suited for us. Cream and butter are on this ground, then, to be ranked above all the other fats or oils in our dietary range. The only carbohydrate in milk is a certain sugar, called "sugar-of-milk," or lactose. Milk contains no starch. The animal body, in fact, does not produce true starch in any circumstances; that is a vegetable product.

The Reason why Starch is Invariably Absent from Milk

The absence of starch from milk corresponds with the fact that the digestive organs of an infant are incapable of digesting starch, though the necessity of making the attempt is imposed upon far too many infants. For at least the first year of life, no starch can be utilised by an infant; and if any food other than milk be given, it should on no account contain any starch. All baby foods and substitutes for or additions to milk in infancy which contain starch are to be condemned outright. The others may or may not be valuable, but the total absence of starch is a *sine quâ non*. The lactose which takes the place of starch in milk is a valuable sugar, not very sweet to the taste,

and notably resistant to many agents and conditions under which other sugars ferment. Other sugars are exceedingly liable to be fermented by the yeast-fungus, producing alcohol, but this does not happen at all readily in milk. Lactose may, however, be readily split up by certain microbes, forming lactic acid; and the sour milk thus formed is as nutritious and useful as before, except for the loss of lactose. On the other hand, it may have some special advantages, as Professor Metchnikoff appears to have shown that lactic acid interferes with the activity of the microbes of putrefaction in the bowel. When sugar is added to cows' milk in modifying it for the uses of an infant, undoubtedly the best sugar to add is lactose itself.

The Presence in Milk of All the Salts that Children Need

The salts of milk are very numerous and important. They naturally require to include all the elements which an infant needs for the purposes of growth, or which an adult needs for the purposes of maintenance. Thus in milk we find salts - beginning with chloride of sodium, or common salt—which include such elements as sodium, potassium, calcium or lime, magnesium, and iron. The amount of calcium in milk is surprising. Lime-water is often added to milk. This may be done for the purpose of diluting the milk, so that it will form smaller curds in the stomach, and that reason is a good one. But lime-water is often added to milk in order to enrich the milk in lime. This is absurd, for milk contains more lime than lime-water, and thus to give the child lime-water when it might be taking milk is to deprive it of lime, and of all the other things which milk contains.

The Protective Power Conferred on Babies by the Mother's Milk

In addition to these well-defined substances, all dissolved or suspended (in the case of the fat) in the water of the milk, there are doubtless several other substances of much importance, as to which we know practically nothing. It is certain that a something in milk is destroyed when the milk is raised in temperature, but what that something is or does we cannot say. The evidence is strong that milk contains substances, derived from the mother's blood, which help the child to resist disease. Part of the immunity of the nursling from certain forms of disease appears to depend upon the fact that it is receiving regular doses of protective substances in its mother's milk. But it is probable that the value of milk in this respect only extends to the cases where the milk consumed is derived from the same species as the consumer. Cows' milk probably contains immunising or protective substances which are valuable for calves, but of no avail for babies.

These are some of the grounds, but there are others, on which modern research is bound to protest against the assumption that any kind of treatment of cows' milk can "humanise" it. The cows' milk can be modified, so that by *nearly* all tests its identity with human milk is demonstrable, but it is not human milk, and has specific differences, still very obscure, but certainly very important, which nothing can alter except the removal of certain things and the substitution of others actually obtained from human milk. The phrase "humanised milk" is therefore misleading.

We have already referred to the absence of condiments from milk, though it is rich in a very large variety of salts. Our survey of its chemistry is far from complete, but it suffices to show us what Nature produces as the ideal food for an infant.

The One Diet Containing Everything that is Necessary, and Nothing that is Unnecessary

We may be sure that nothing not present in milk is necessary for health, and even that, the further we depart chemically from the composition of milk, the more likely we shall be to commit dietetic errors. This is the one diet which contains everything necessary and nothing unnecessary; which yields the highest percentage of absorption by the body of the nutriment it contains; and which throws the least strain upon the excretory organs. Thus, in acute inflammation of the kidneys, such as sometimes follows upon scarlet fever, and in all other conditions of danger to those necessary organs, the dietician proceeds to eliminate all other factors from the diet and to trust in milk alone, for he knows that it will yield a maximum of nourishment with the minimum of irritation. If the reader is not now convinced of the personal and national importance of a proper supply of this invaluable food, which now spreads disease everywhere throughout the land, we have written in vain. We have no such proper supply at present, and the obtaining of one is the most urgent problem in our national nutrition at the present time, when we are in the extraordinary position that our most valuable and necessary food is the chief agent in the spread and maintenance of our most deadly diseases.

SPACE-DEVOURING SPEED BY LAND, AIR & SEA

TYPICAL EXAMPLES OF THE MACHINES THAT ARE SPEEDING UP THE LIFE OF THE WORLD

their ancestors surprised the now disappearing aborigines. Moreover, nearly all the young nations are so closely connected by blood, or common interests or alliances of interests, with the Great Powers that the rapid instruments of modern warfare cannot be brought against them.

Yet the struggle for dominion still goes on, speed still being the weapon of victory. The foremost industrial peoples of the modern world are holding up to ransom the ancient overcrowded civilisations of Asia, means of the pace at which they work industries and conduct their commercial and financial operations.

M municat

turbing Effect of Industrial Speed Handicraftsmen of the East

to place, have all been team-power, electricity, gasordinary manner. power, they are racing to send a message, a hu dustrial production; could transmit it no faster peed in manuthe Great had done. Indeed, his messenger of victory—a man mounted on a horse—could travel no quicker than our remote forefathers, who swept from Turkestan on the swift animals they were the first to tame, and conquered Babylonia and Egypt, Asia Minor and Greece, by the sheer rapidity of their warlike movements. Many thousands of years have passed since the ancestors of the Northern European races overturned the world, and spread from Ireland to China, simply by a new speed of travel acquired by bridling and mounting the wild horse.

This was the first historic feat of the now dominant race of the earth. It was the horse that long afterwards enabled some of their descendants to destroy the empires of the New World, and subdue the even more warlike barbarians of the forests and prairies of Northern America. Other things being equal, the battle is to the swift. This applies not only to war but to the industrial struggle. Our remote forefathers' victory over the Babylonians and the Egyptians was transient. They became a small military caste in the midst of large and busy nations of craftsmen; they could not apply their horse-power in industry, and so they were at last overcome by the more civilised races that they had taken by surprise. It was only in Northern Europe and Northern India and Persia that they managed to retain the territory they had won by horsemanship. Never in after times at the height of their power did they recover the difficulty; and on the success of the measures which they take to overcome it depends entirely the length of their existence. As it is extremely doubtful if they can restore to China its ancient exclusiveness, their only practical course seems to be to imitate Japan—introduce machinery and the factory system, and speed up the whole industrial life of the Chinese people. The grand problem is whether the Republicans can effect this revolution in a manner rapid and wide enough to save the vast multitudes of half-starving handicraftsmen from the misery that is the direct cause of their rebelliousness. If the Republicans fail in their tremendous task, China will fall into a condition of unparalleled anarchy and poverty, the end of which cannot be foreseen. One probable result will be that the Chinese market for foreign goods will be destroyed. This is perhaps the reason why enlightened bankers are inclined to finance the new Republican Government.

Our own Government must surely sympathise with the leaders of the Republican in China, for we have the same by means reaching importance arrows with a speed force possessed by no other missile of war. But rapidity in the instruments of battle is no longer the main power of dominion. The invasive force of the white races is practically exhausted. Their big guns, it is true, throw an immense shell of murderously explosive power for a long distance at a speed of 2000 miles an hour at the start; and their rifles send the new pointed bullet from the muzzle with the same deadly velocity. Their railways and steamships enable them to collect and transport enormous bodies of troops at twice or three times the speed which a mounted man, with relays of horses, can travel. But all these new and extraordinary powers of striking swiftly and travelling swiftly do not avail in the fundamental struggle of the races of the modern world. Practically, all the territory that could be acquired for new settlements by warlike means has now been acquired by the nations that were first to seize the new opportunities for expansion. The plantations made by these nations are now growing—or have grown—into great and powerful dominions as capable of resisting aggression as are the older States. And the quickness of modern communications prevents other people from taking them by surprise in the way that

THE SWIFTEST MODE OF OCEAN TRAVEL FIFTY

THESE TEA-SHIPS OF THE 'SIXTIES, RACING FOR THE MARKET, LEFT CHINA ON THE SAME DAY AND REACH-

heir ancestors surprised the now disappearing aborigines. Moreover, nearly all he young nations are so closely connected by blood, or common interests or alliances of interests, with the Great Powers that the rapid instruments of modern warfare cannot be brought against them.

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The Disturbing Effect of Industrial Speed on the Handicraftsmen of the East

Armed with steam-power, electricity, gas-power, and water-power, they are racing against each other in industrial production; and they have attained a speed in manufacture, transport, and distribution against which the nations of handicraftsmen vainly and very painfully contend.

Unlike our ancestors in ancient Babylonia and Egypt, we have a speed in industry which is more deadly and terrible than speed in war. For good or for evil we have "speeded up" the whole human life. It is more difficult to resist our industrial aggressiveness than it is to withstand our military weapons. It is the speed of our modern machinery of manufacture that is he fundamental and direct cause of all he political and social revolutions that are disturbing the chief peoples of Asia. At the bottom the unrest in China, for example, is the new and dreadful pace at which the main industries of the great white nations are carried out. The Chinese craftsman has been out-raced and impoverished by English, German, and American manufacturers, who, with the aid of railways and steamships, send their rapidly made products to compete in the craftsman's own village with the articles he slowly makes with his hands.

The Problem of China—Can She Adopt Modern Methods of Speed in Production?

The Boxer movement was a wild and blind attempt on the part of the Chinese working people to drive the foreigner and his foreign goods out of China, and seclude that country again from the rest of the civilised world. The Manchu Government was overthrown because it showed itself too weak to resist the commercial as well as the military aggression of the white races. The leaders of the new Republican Government are faced with the same difficulty; and on the success of the measures which they take to overcome it depends entirely the length of their existence. As it is extremely doubtful if they can restore to China its ancient exclusiveness, their only practical course seems to be to imitate Japan—introduce machinery and the factory system, and speed up the whole industrial life of the Chinese people. The grand problem is whether the Republicans can effect this revolution in a manner rapid and wide enough to save the vast multitudes of half-starving handicraftsmen from the misery that is the direct cause of their rebelliousness. If the Republicans fail in their tremendous task, China will fall into a condition of unparalleled anarchy and poverty, the end of which cannot be foreseen. One probable result will be that the Chinese market for foreign goods will be destroyed. This is perhaps the reason why enlightened bankers are inclined to finance the new Republican Government.

Our own Government must surely sympathise with the leaders of the Republican Party in China, for we have the same problem of vital and far-reaching importance to solve in India.

How the Defeat of the East by the Machinery of the West Affects India

The tremendous speed of our productive machinery is beginning seriously to affect the position of slow manual native workers all over India. They, too, cannot keep up with the pace we have set by our machines and new methods of industrial organisation. Practically all the unrest in India is founded on this fact; and the attempted boycott of British goods was mainly, like the Boxer movement in China, an attempt to defend the native handicraftsman from the speed and cheapness with which we conduct our manufactures. For the cheapness of our machine-made goods is only a derivative characteristic; their cheapness is derived from the speed at which they are turned out. As in the case of China, there are two possible way of helping the Indian working people. One school of Indian reformers wants to erect a high tariff-wall around India, in the shelter of which the native craftsman may be able to work in his old way. But it is clear to others that the only sure and permanent remedy is that found by the men who are extending the factory system and the use of machinery in India.

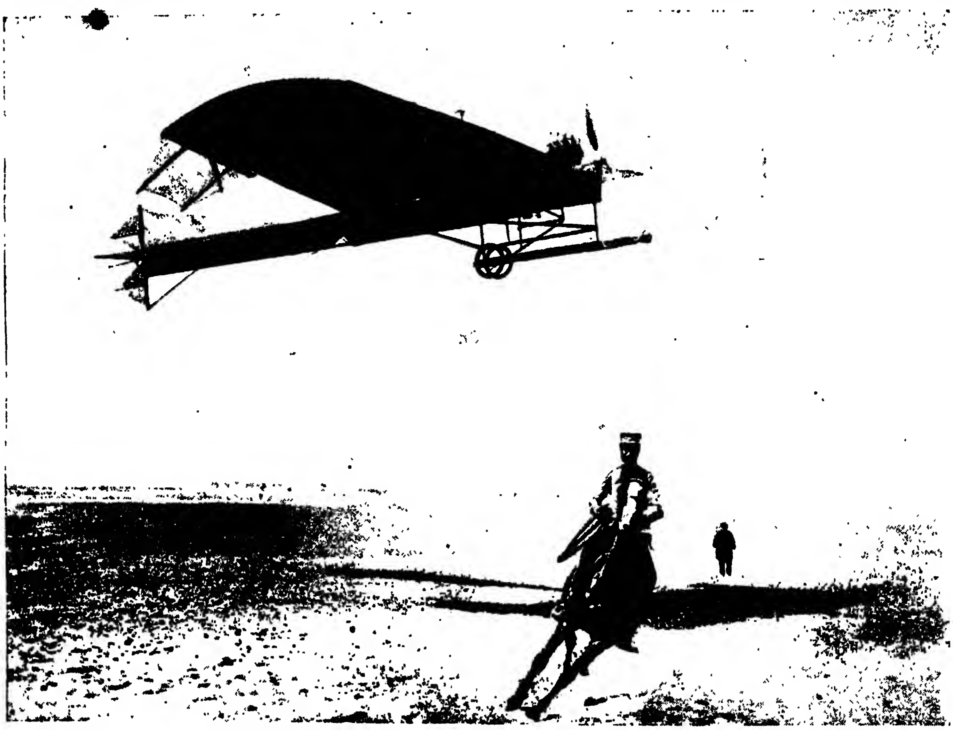
Only by a general "speeding up" of the industrial activities of the Indian peoples

will they be able to work at the pace set by Europe and Northern America. If the Indians and Chinese had sufficient agricultural land and pasture land to grow corn and meat for the industrial races as well as for themselves, they could escape from the competition of our machinery. But, far from owning any of the great granaries of the world, they are suffering from over-population, and often need to import food to mitigate the miseries of widespread famines. Thus there is no alternative before them but either to seclude themselves entirely from the rest of the world, or follow Japan in the general establishment of the machinery and organisation of modern industrialism. We must all allow that speed in productiveness is not everything, any more than rapidity of fire and movement in war is everything. Many a nobly brave race has suffered defeat owing merely to the fact that its weapons were mechanically inferior to those of its opponents.

The old traditional ways of life of a handicraftsman are more pleasant and more picturesque, and in themselves often more healthy, than the mode of existence of a factory hand. Yet, when it is a matter of life and death, the bow and arrow of the Chinese soldier must be thrown aside for a modern rifle. So with the instruments of work of the Chinese and Indian artisans. In their own interests, and in the general interests of humanity, most of them will be compelled, sooner or later, to work at the racketing, tearing pace set by modern machinery.

The real problem of their future is a question of intelligence and character. We can speak with no first-hand information on the matter, but we have been told that a very considerable proportion of the mixed races of India do not seem to possess the intellectual power necessary in the higher branches of modern manufacturing methods. When a machine goes slightly wrong, they have no idea of its construction, and they are utterly unable to put it in order. It is said that they cannot even be entrusted with the routine care of machinery.

This is probably due in many cases to a lack of education and training in the most elementary kinds of engineering. At least, we hope so. For if the average Indian artisan were naturally incapable of understanding the working of machinery, he would rank with the child-races of the world,



A MEETING BETWEEN THE NEW AND THE OLD SPEED-AGENTS OF MAN—A HORSE SHYING AT AN AEROPLANE IN THE DESERT OF TRIPOLI

whose mental development is some hundreds of thousands of years behind that of the highly civilised peoples. Certainly there are some low mental types among the Indian natives, and the curious and intricate system of castes seems to have been established partly with a view to preventing the intermarriage of the finer races with the worse. Judging from Indian thought and literature, art and craftsmanship, we incline to the hopeful belief that the general level of intelligence in India is not so low as to make it for ever impossible for the now defeated craftsmen of the nation to use modern machinery in recovering the ground they have lost.

SPEED PRODUCED SOLELY BY THE MUSCULAR ENERGY OF MAN — A RACE FOR THE WORLD'S SCULLING CHAMPIONSHIP

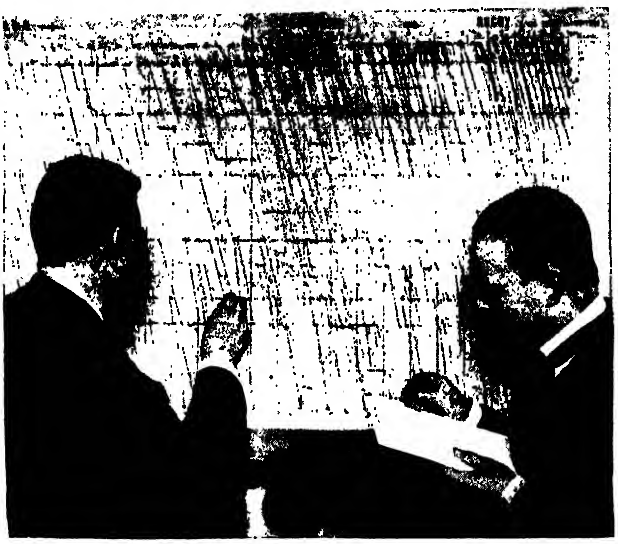
Certainly the Hindus of the higher castes are equal to Europeans in intellectual power; and by becoming the leaders of the new industrial movement they should be able to give that movement the necessary direction and impetus. In the case of the Chinese worker there can be no question of his mental ability. He would equal the European and American artisan, especially on the technical side of manufacturing processes. For he has for centuries—nay, for thousands of years—been remarkable for ingenuity of talent and quiet tenacity of character. If it were possible to speed up the entire industrial activities of the Chinese people in the next hundred years, they would effect a profound and widespread revolution throughout the civilised world. As has been said, they would "under-eat us and overwork us." Long before the period at which their extraordinarily frugal and simple standard of life had risen to the level of comfort and nourishment that the white artisan requires, the Chinese factory hands would ruin some of the chief industries of Europe and America.

This is the real Yellow Peril. It is more menacing than the nightmare of Mongolian hordes, armed with the latest artillery and sweeping across Asia into Europe, that used to disturb the slumber of the present German Emperor. If our strong-handed action in opening up free markets in China against the will of the Chinese were eventually to lead to a majority of the Chinese people becoming industrially efficient, we should be in a worse position in the end than Frankenstein was when he created his mechanical monster.

Happily, perhaps, for our grandchildren, or great-grandchildren, it is very doubtful if

China will ever be able to become a vast industrial nation, with all the intricate modern machinery of speed. Food is already so scarce there, in spite of the patient skill with which the peasants grow their crops without exhausting the soil, that hardly a man can be spared of all the millions now employed in agriculture. Indeed, China needs more farmers and farm labourers in order to nourish her extraordinary population. For the effects of the law of Malthus in regard to the growth of population and the exhaustion of food supplies is now operating in many parts of the new Republic. It is thus impossible to withdraw at present, on a large scale, the Chinese people from the land to fill the factories. Japan was able to establish a considerable number of industrial armies by conquering Korea, and turning it into a granary for her working people. China has neither the power nor the opportunity of doing anything like this. So she must, it seems, pass through a long period of domestic trouble, dreadful to contemplate, during which her starving handicraftsmen will perhaps drift to the sea-coast towns. And there, if foreign capital and foreign management are available, they may be reorganised into industrial efficiency. Neither for them nor for their nation can the outlook be said to be immediately prosperous. China is paying a very heavy price for her long period of sleepy stagnation, and it is impossible to predict what the outcome will be.

It was our country that set the pace; and one of the results of our new passion for speed in all directions is that the Anglo-Celtic peoples have become generally rich. It is true that the cost of living has doubled in the last hundred years, but wages in the same period have, on the whole, increased four times or more. And, what is of greater importance, our new and rapid machinery of production, transport, and distribution has brought about a general levelling up in most of the necessities and many of the luxuries of civilised life.


SPEEDING UP ON THE RAILWAYS—PLANNING A CROWDED TIME-TABLE BY THE AID OF THREADS

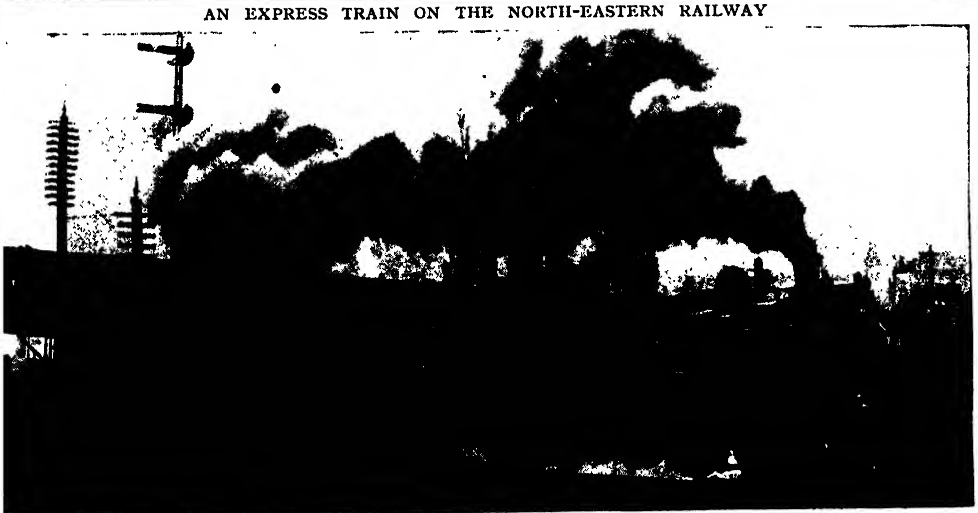
Most of us are probably inclined to think that the pace at which we now work is more than sufficient for the purposes of our civilisation. But it seems likely that we are entering upon a new and faster stage of industrial activity. A few years ago, the discovery of high-speed steel was made, and it is revolutionising many important branches of industry. The machines themselves that do so large a part of the work of the civilised world can now be made more rapidly by means of a new cutting-tool. Until lately the instrument that planes down iron and steel, just as if they were wood, could not work quickly. A good deal of the energy used in making the cut was transformed into heat, most of which was absorbed by the tool. The result was that its cutting edge quickly lost its temper and became useless. So the work had to be carried on at a snail's pace.

But in 1894 Mr. Frederic W. Taylor, who had been engaged by the Bethlehem Steel Works to increase the efficiency of both their machines and their men, resolved to find a speedier tool for shaping steel and iron. He caused fifty thousand tests to be made on a million pounds of steel and iron, at a cost of £40,000, and in the end discovered that, by subjecting an alloy of steel and tungsten to a terrific heat, he could obtain a material that could cut through hard metal almost as easily as sharp iron cuts through timber. While the ordinary tool of carbon steel cuts from twenty to twenty-five feet of steel chip a minute, the high-speed tool has been known to cut four hundred feet a minute. Impelled by a stress of a hundred tons behind

TYPES OF MILE-A-MINUTE ENGINES

A BOAT EXPRESS TRAIN ON THE LONDON, BRIGHTON, AND SOUTH COAST RAILWAY

AN EXPRESS TRAIN ON THE NORTH-EASTERN RAILWAY



AN EXPRESS TRAIN ON THE CALEDONIAN RAILWAY

it, it pares off hard steel just as if it were working on a mass of cheese.

Such is the discovery which promises to change the gigantic industry on which modern civilisation rests. Already it looks as though the high-speed tool has altered the position of the workmen who began to use it. The limit of their physical endurance has been reached, and an entire change must be made in the method of doing the work. Automatic machinery will probably be substituted for hand-labour.

This, however, is only the beginning of a general revolution in almost every branch of modern industrial life. For Mr. F. W. Taylor resolved to make the human machine as efficient as a high-speed tool. The steel tool was, in fact, only a by-product in a general attempt to speed up both the instruments of work and the workmen. In Taylor's opinion—which we give for what it is worth—" American and English workmen work at sport and play at work. In a majority of cases they deliberately plan to do as little as they safely can. They believe that if they work at their best speed they throw a lot of other men out of work. So they 'ca' canny,' as the Scots workman says, or 'hang it out,' as his English comrade puts it—'soldiering' being the American artisan's term for the same process."

Mr. Taylor declares that, for every person who is overworked, there are a hundred who intentionally underwork. Believing that increased speed of production makes, in the end, more work for more men, he has devised a scientific system of "speeding up" every kind of labour, which has had an influence throughout the civilised world. It is stated on good authority that already fifty thousand workmen in the United States are employed under the system, that brings them 30 to 100 per cent. increase in wages; and one of the Deans of Harvard University has stated that scientific management, as Taylor's "speeding-up" system is called, promises to be the most important advance in industry since the introduction of the factory system and steam machinery.

Mr. Taylor started in life as an unskilled day-labourer in some steel-works in Philadelphia, but he was soon advanced to the position of a foreman. Then he worked out his new system, and in 1898 he was asked to reorganise the Bethlehem Steel Works. By this time he had gathered around him a small but brilliant staff of scientific managers, and under his direction they tackled the problem of the unskilled labourer.

There were some eighty thousand tons of pig-iron stacked in small piles in a field near a railway line, and a gang of seventy-five men, under an excellent foreman, was putting the iron into railway trucks. Each pig of iron weighed about ninety-two pounds, and the gang loaded the trucks at the average rate of twelve and a half long tons a man a day. This was as fast work as was done anywhere at the time. But Taylor and his staff began to carry the pig-iron themselves, and to study the way in which the gang laboured, and they came to the surprising conclusion that a first-class pig-iron handler ought to handle forty-seven long tons a day, instead of twelve and a half.

They noticed that one little man trotted home for a mile after his work, about as fresh as he was when he came trotting up in the morning. They asked him if he would like to earn seven-and-sixpence a day instead of four-and-eightpence. Naturally he was willing. So one of the staff stood over the little handler, a watch in hand, and directed his every movement. "Now pick

AN EXPRESS GOODS TRAIN HURRYING PERISHABLE PRODUCE TO MARKET

THE DANGER THAT LURKS IN ALL SPEED

The scene portrayed—a scene more than possible in America—suggests, symbolically, the ever-present danger of the modern pace.

The photographs on these pages are supplied by the Burroughs Adding Machine Manufacturers, The Locomotive Publishing Co., S. Cribb, and others.

A TORPEDO-BOAT-DESTROYER, THAT RIVALS IN SPEED THE AVERAGE RAILWAY TRAIN

A TORPEDO-BOAT-DESTROYER STEAMING AT FULL SPEED. A PACE OF OVER FORTY MILES AN HOUR HAS BEEN REACHED BY THESE VESSELS

up a pig and walk! Now sit down and rest! Now walk—now rest!" So the directions went on, the aim being to see that the man regularly worked at his highest speed, and then regularly gave all his muscles a complete rest. At the end of the day he had loaded forty-seven and a half long tons, and he trotted home as fresh as ever. One man after another was picked out and made to handle pig-iron at the rate of forty-seven and a half tons a day, until all the pig-iron was handled at this rate, and all the gang were receiving 60 per cent. more wages than other workmen around them.

It must be remarked, however, that only one man in eight was able to work at the high speed set up by the scientific managers. The other seven were dismissed, and new men taken on in their place. This stern process of sifting human capacity is a main feature of the new system of industrial efficiency. It is true that at the Bethlehem Steel Works the men who were rejected were immediately given other jobs, and the management held that the removal of these men from work for which they were unfit was a kindness to them. For they were able to get training for other tasks at which they could earn permanently higher wages. But it seems to us that if the principles of scientific management were universally applied, the vast multitude of naturally slow workers would have great difficulty in getting a training for the lower position to which they were assigned by the experts. There have already been strikes in America against the sifting out process.

Next followed the destruction of the gang or group method of work. For Mr. Taylor and his staff contend that when men work in gangs the individual efficiency falls below that of the worst man in the group, and that men lose their ambition and their initiative when they are herded together, instead of being treated as separate personalities. So in the Bethlehem Works not more than four men were allowed to work in a group. There was no foreman or overseer to keep them up to the mark. It was when their work was done on their own responsibility that they were judged. There were no disputes or nagging; the work spoke for itself.

Each shoveller, for instance, was given a truck to fill within a certain time. He did the work of four men, without undue fatigue, and received 60 per cent. advance in wages. Only 140 shovellers were then required instead of 600. So, in spite of the increase in the individual wage, the company saved £16,000 in one year in the shovelling yard alone. The shovellers were provided with new kinds of shovels, carefully designed for the various purposes for which they were used, with a result that they shovelled fifty-nine tons a day instead of sixteen tons under the old gang system. Each kind of workman was in turn taken in hand by the scientific managers; and when the task of "speeding up" the entire production of the great steel-works was completed, most of the men were saving money, and all of them were living better than before. They were practically all sober, for no drunkard could keep up the new pace of work.


THE FAST MOTOR-BOAT FOR PLEASURE AND SPORT

The most important thing about the new "speeding up" system is that it pays. It pays both the employer and the employed. But it is much too early to discern what effect it has on the human machine. Mr. Taylor argues that no man's constitution is injured by his way of increasing the rate at which work is done. He has applied his new principles to an astonishing variety of trades—to bricklaying and the running of railways, to the machine-shop and to concrete work. In every case he has raised wages and lowered the cost of production, by increasing the speed of the workmen. He has even shown that, as a matter of pure business, it pays to provide workmen with good dwellings, pleasant surroundings, and free means of recreation.

He tries never to tax the bodies of the men on whom he experiments so as to diminish the length and permanence of their powers at labouring continually at a higher pace than is usual in modern civilisation. Yet we cannot help doubting if the new industrial

system will leave a man who comes under it in youth in a condition of vigorous old age. Mr. Taylor, again, has made a study of the movements necessary in any kind of work, and seeks to eliminate all that is useless in the traditional way of doing a thing, devising improved instruments that lighten the toil of the workman. But when he sets the best man he can find to create a record speed in productiveness, and then compels other men to keep up every day to this record, he seems to us to be putting too continual a strain upon the human machine. It would be surprising if we did not hear that, in works rigorously conducted on the new system, nervous breakdowns among the men have become alarmingly frequent and numerous.

The fact is that Mr. Taylor appears to have created a rather terrible engine of speed, which is capable of being misused. It certainly helps the American employer of low-class emigrant labour to sift out quickly the best men from the slackers, and solves one of the most pressing industrial problems of the United States at the present day. But if this extraordinary and rigorous method of standardising high-speed labour comes at last into general use throughout the civilised world, it may be transformed into an instrument for grinding the last spurt of work out of the workman. A good number of men can walk five miles an hour, but it is impossible to get a large body of infantry on a long march to do much more than three miles an hour. Already some of our great industrial works have elaborated a system of efficiency that has much in common with Mr. F. W. Taylor's high-speed management. It is, however, in these works that extreme Socialistic doctrines and an intense and passionate feeling of revolt against the new conditions of labour are rapidly spreading.

Whatever may be the fate of this special movement for working the human machine at its top speed, it is certain that the general speed at which modern manufactures are now produced is bound to go on increasing. Though it is more than a hundred years since steam-power was first employed in industry, we are still at the beginning of the new epoch in the productive activities of the human race. For even if the human machine is not "speeded up" to double its present pace, yet the innumerable machines of metal will be continually endowed with more rapid powers of work, by the army of inventors variously engaged in improving all labour-saving devices. It is by the speed and alertness of their inventive genius that the most highly advanced of civilised nations keep in the forefront of our industrial civilisation. It is a race of mind against mind in the arts of both war and commerce. That is why the results of the long stagnation of China now appear so pathetic. Not many hundred years ago the civilisations of the Orient and the civilisations of the Western world were walking all at the same pace, level with each other. Even a hundred years ago we had not drawn far ahead.

Eight miles an hour was the pace at which a traveller then went to Scotland—less probably than that at which the Emperor Severus of Rome travelled through his British dominions. A few striking mechanical aids to labour had been invented in the arts of spinning and weaving, and a steam machine for pumping water out of mines was of remarkable construction.

OIL-DRIVEN COASTAL TORPEDO-BOATS TRAVELLING AT FULL SPEED

Simply by putting this pumping machinery in an improved form upon a truck, the modern railway came into existence. By adapting the same pumping-machine to supply power to mills and factories and workshops, the great industrial revolution was engineered. China is still walking, restless and discontented now, at the old, slow, comfortable pace, but we have railways and motor-cars, and flying-machines with a speed of a hundred miles an hour or more.

Indeed, at a trial run of an electric train, on a straight and level line, the incomparable speed of travel of 130½ miles an hour has been achieved. At another trial run on the Munich-Augsburg line of the Bavarian State Railways, a steam locomotive pulled a train weighing 150 tons at an occasional speed of ninety-six miles an hour, and a mean pace of nearly eighty-one miles an hour. In ordinary everyday runs, many express trains in England and abroad travel between seventy and eighty miles an hour on some parts of their journey, in order to arrive at the scheduled time. Over all the civilised world the standard of speed in travelling has risen insensibly and is still rising. Eighty miles an hour is the maximum speed realised at present, but some railway engineers think that one hundred miles an hour could safely be attained by altering some of the curves of the rails.

On fairly straight and well-laid railway lines, the maximum speeds are largely governed by considerations of economy. Many railways do not run their trains as fast as is safely possible, simply because the extra cost of a high-speed service is not balanced by an increase in a number of passengers. Some of the services on our principal railways are slower than they used to be forty years ago, owing to the fact that it was found too expensive to carry a comparatively few passengers to London at the pace of about a mile a minute. On the other hand, many of the railways of the world were constructed at a time when the speeds and other conditions obtaining today were not contemplated or thought possible. Most of these lines have sharp curves and steep gradients that render quick travel very perilous.

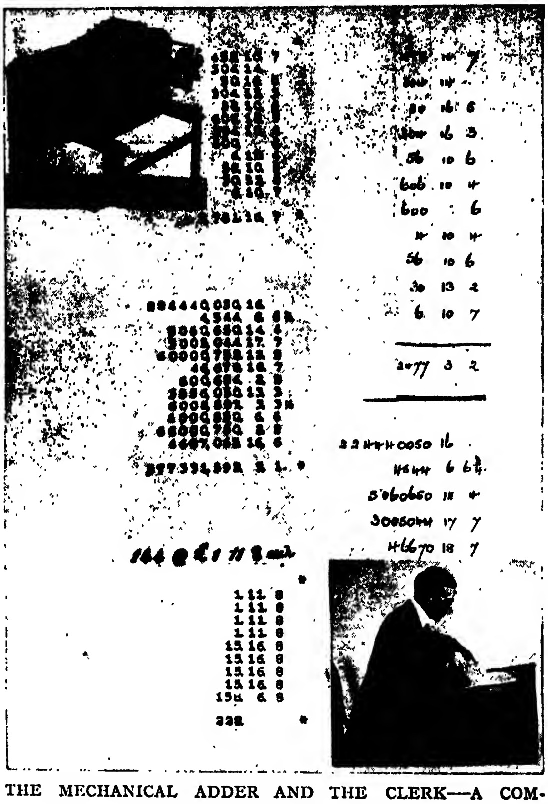
All these lines would have to be partly rebuilt for a train to run safely along them at a speed of eighty miles an hour. It is commonly thought that simply by banking or raising the curve of a railway-track it may be made secure for any speed. But as a matter of fact this banking is carried out entirely for the comfort of passengers, so that they may not feel the carriage lurch and jolt in entering and leaving the curve. Far from being safe, the banking may be a source of danger in very high speeds. Perfect alignment, with at times a transitional and more gradual entering and leaving curve, is the only safe method of rounding a corner in a rapid train. Probably a hundred miles is the absolute limit of speed with our present means of steam locomotion.

Yet it is not impossible that our descendants may be able to travel at a speed of 1000 miles an hour. At least, this is the limit at which the human body could be hurled through space. In the first half of the journey the backs of the passengers would be pressed hard against the seats. In the second half of the journey they would have to struggle hard to resist the

A RACING MOTOR-CAR TRAVELLING OVER EIGHTY MILES AN HOUR

tendency to pitch face forwards, but this could be obviated by turning their chairs round in the middle of the journey. All this would be due to the fact that the working of the train would be determined by the problem of starting and stopping it. The quickest way to get from one place to another is to travel fast and faster until half the distance is covered, and then slow down gradually to the stopping-place. This is why the passengers would be thrown against their seats in the first part of the journey, and then, if the chairs were not turned, pitched forward when the train began to slow down. It is reckoned that 1000 miles an hour is the utmost acceleration that the human body could just bear in comfort. But the train would have to run on the air, and never touch the rails.

It may seem absolutely impossible to send a train along at a terrific speed without touching the track. But there is already in existence a train that moves on air and yet keeps to the track. It is the invention of Emile Bachelet, a French engineer, now resident in America. In his workshop at Mount Vernon, a suburb of New York, Bachelet has built a small experimental line, over which a small locomotive flies at a speed of 300 miles an hour. The invention is based on the fact that, while a direct electro-magnetic current attracts metals, an alternating current exercises a powerful repellent force, especially on aluminium. Electro-magnets are placed at an interval of one foot along the line, and on the magnets rests a torpedo-shaped steel car with a bedplate of aluminium. On turning on an alternating current of 110 volts, the small car can be made to rise half an inch in the air, through the repellent electric current acting on the aluminium. A force of 220 volts sends the car an inch higher. It is held in position by upper and lower guide-rails, with which it is connected by brushes; these sustain none of its weight, but serve to keep it steadily moving on its course. The car's position in the air is due entirely to the action of the alternating current.

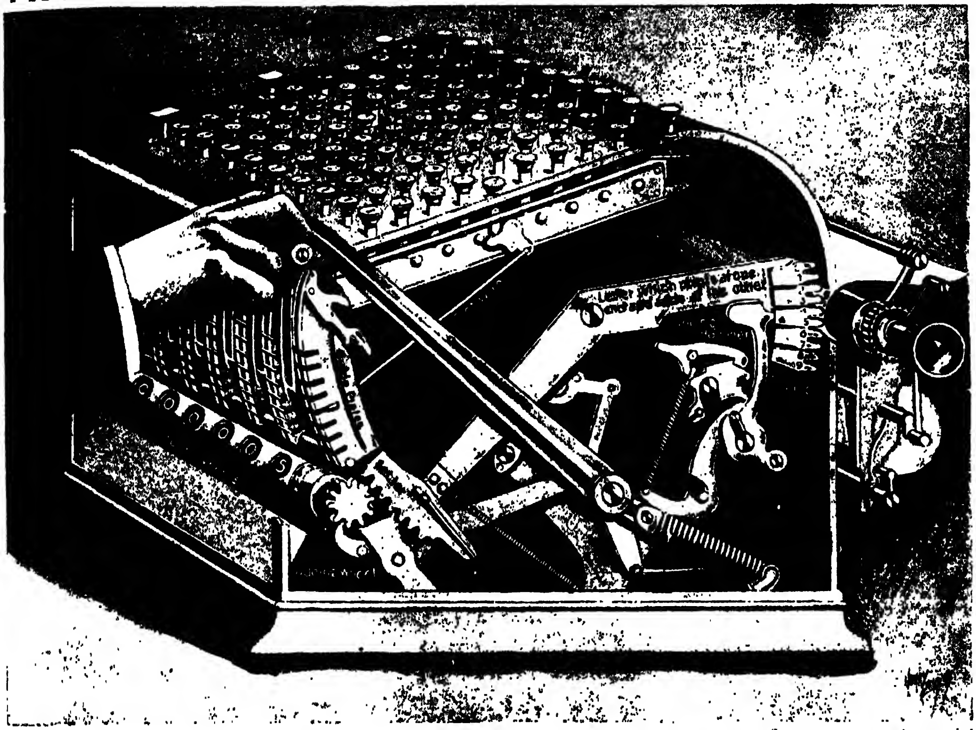


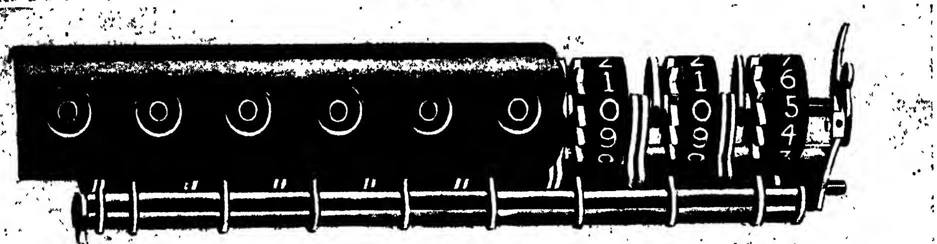
THE MECHANICAL ADDER AND THE CLERK—A COMPARISON IN WORK DONE

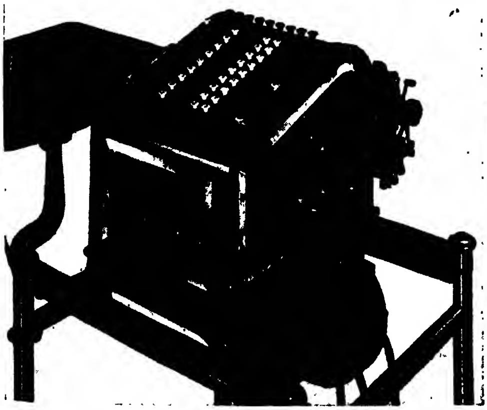
At the opposite ends of the line are two coil magnets. By turning a direct electric current into one of these magnets the car is sent through the air like a shell from a big gun. It is brought to a halt by shutting off the electro-magnetic force, while another turn at the switchboard directs the electricity through the coil magnet at the far end, drawing the car in the reverse course. Bachelet estimates that the cost of the electrical energy necessary to keep a two-ton car in the air for one hour is only fourteen shillings. As all the causes of retarding friction are absent, a speed of five miles a minute is easily obtained, and by increasing the number of coil magnets along the line a much more rapid movement could be produced. The inventor has not yet worked out the cost of constructing and working his new railway and train on a large scale. The speed is so terrific that he intends first to adapt his flying locomotive to transmitting letters and parcels over long distances. When some of these new tubes have been built, and got into good working order, it will be time to think of building wider tracks and heavier cars for the transport of passengers.

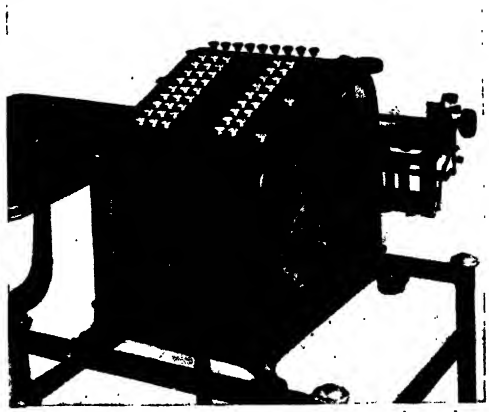
We are informed that on the small scale with which Bachelet is at present conducting his experiment his flying train is a

ARITHMETIC SIMPLIFIED BY MACHINERY









This wonderful machine prints a column of figures, adds them together automatically, and prints the total. The upper picture shows the work of a lever, of which there is one for each column. When a key is depressed—say, 5, as in the drawing—the sector drops five points, being regulated by a slot wire attached to the key. At the same time the other end of the lever is raised 5 points, bringing an attached type figure 5 opposite the spring hammer. This hammer, actuated by the operating handle, strikes the type figure and prints it. As the handle returns, the rack on the sector engages with the cogs of the adding wheel, turning the wheel five figures forward. Other figures are added to the wheel in the same way, up to 999,999,999 on the machine illustrated. The total is printed by pressing down a key and drawing down the operating handle, though some machines are worked by a small motor. The centre picture shows the front of the adding wheels, three being shown uncovered, and the two photographs show the machines themselves.

wonderful success. But until expert electrical engineers have calculated the cost of using the flying train on a long line for dispatching letters and parcels, it is impossible to say if the invention is practical. Electricity is still rather dear to manufacture, and a good deal of electric energy would be required to keep a heavily laden car suspended in the air over a course of many miles. Yet the flying train shows that there are methods of wonderfully rapid locomotion which may one day be at the service of the human race.

Inventions that May Further Speed Up Travel and Trade

In the meantime the Brennan mono-rail or the Behr high-speed railway, both already described at length in POPULAR SCIENCE, may profoundly revolutionise the speed of land travel, and scatter the great cities over the green and pleasant country-side, and not only help to return manufactures to their original home in country places, but, by saving time, add appreciably to the leisure which is the just due of every worker.

It will be more difficult to abridge the vast and stormy spaces of the main seas than to shorten the time distances of land travel. Remarkable as are the speeds of the "Mauretania" and the new battle-cruiser, H.M.S. "Lion"—the two great ships that now hold the record for rapid ocean voyages—they compare but poorly with the pace of an ordinary express train. The new type of flying-machine that can cross the seas at the rate of a hundred miles an hour may develop into the ocean greyhounds of the future. But this is possible rather than probable. For though a French artisan, A. Moreau, of Combes-la-Ville, seems to have partly solved one of the problems of the automatic stability of the aeroplane, it may be hundreds of years ere the expresses of the skies become as safe and steady as the fast ocean liners of the present day. And a miracle of invention will be necessary to make them as secure a means of travel as a railway train.

The Probable Limit of Speed Across the Broad and Stormy Seas

So it is likely that for many years to come forty miles an hour will be the limit of speed over the seas and oceans that divide the peoples of the earth. Only by tunnels and ferries will Ireland be brought much nearer to Britain, and Britain nearer to the Continent, except for such adventurous travellers as are ready to challenge danger, notwithstanding the appalling length of the airman's roll-call of disaster. No doubt, speed in itself is not always a desirable thing. Yet, as we have seen, the battle, in industry and war and general organisation, is still to the swift. And as long as men compete together they will make machines to work for them, and carry their messages and the materials they require, at a fast and faster pace. And the train, and the motor-car, and the flying-machine, and even the ships that face the perils of the sea, will be urged forward at increasing velocities. The strange new human passion for speed is often distressing, and sometimes dangerous, but it can hardly be said to be unnatural. Like the young lady in one of the Gilbert and Sullivan operas, "we are the children of Nature, and we take after our mother." At least, we live in a universe of whirling masses that often have an extraordinary and complicated rate of motion. Our planet, for example, spins and curves and shoots through space in a series of very fast and triple movements.

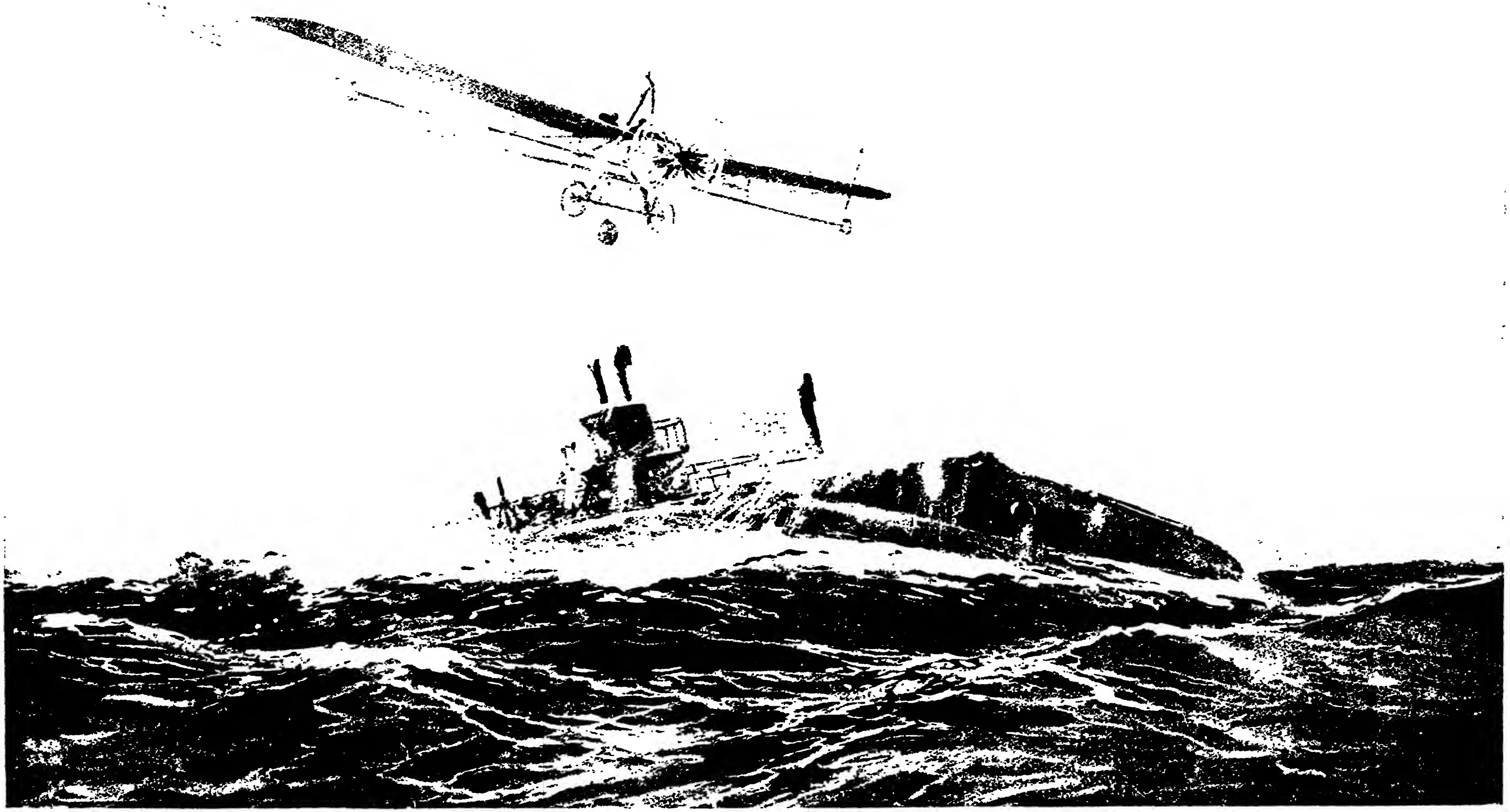
The Inconceivable Speed of Worlds and Molecules that We Do Not Notice

In its daily rotation from light to darkness it turns at the equator with the half-speed of a bullet from a rifle—a thousand miles an hour. At the same time, in its annual swing round the sun it sweeps onward 66,000 miles an hour. In addition to this, the entire solar system is flinging itself along the heavens at the pace of about four thousand to five thousand miles an hour.

We might say that speed is existence, for nothing exists in a state of rest. Even the atom has been broken up, revealing a complex system of electrical charges, whirling round a central core of electricity, like planets round a sun. And when two or three atoms combine into a molecule, these molecules in their gaseous state acquire terrific velocity. It has been calculated that a molecule of nitrogen gas has a velocity of about 1100 miles an hour; but as it is jostled by other molecules, receiving 8000 million impacts a second, it does not get very far. Still, movement is existence, in both the largest and the smallest masses.

It has lately been discovered that all the stars of the heavens form two streams, moving in opposite directions. When they are young their speed is comparatively slow, but as they grow old their strange, mysterious movement becomes more rapid. The chemical change in their elements, as they turn from a white to a red heat, produces an electrical change, and by some

THE NEVER-CEASING CONFLICT BETWEEN CUNNING AND SPEED



THE ADDED HORROR THAT MAN'S DEVELOPMENT OF SPEED BY THE WAY OF THE AIR HAS BROUGHT TO MODERN WARFARE ON THE HIGH SEAS

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process still unexplained they then increase their speed, moving at times at a velocity of 210,000 miles an hour. And just lately much higher speed than this has been noted. It is thought that the attractions and repulsions of an electromagnetic force existing throughout the universe explain both the phenomena of gravitation and the streaming swirl of all the stars in two parallel lines.

As is well known, the light that the stars emit is also an electric phenomena. This was finally proved when Hertz discovered the existence of electric waves. For an electric wave and a beam of light travel at the same enormous velocity—186,400 miles a second. This comes to more than 670 million miles an hour. So far as we know, this is the highest speed of any natural force in ordinary circumstances.

One would think that it was a mad impossibility for a creature existing on an insignificant planet whirling round an unimportant star, lost in the mighty universe of flaming suns, to devise a means of obtaining a speed greater than that of light and electric waves. Yet man, the little lord of a little clot of dust spinning round a little star, has obtained so marvellous a control over the electromagnetic force out of which the entire fabric of the universe is formed that he can make it carry his messages along a copper wire at a velocity of 1041 million miles an hour.

WHERE SPEED IS NEEDED MOST—THE SELF-RAISING FIRE-ESCAPE, OPEN AND CLOSED

Wheatstone did this, in a famous experiment with a mile of telegraphic wire, divided in four sections, each a quarter of a mile in length. Our telegrams, however, are never flashed through wires and cables, in ordinary circumstances, at this supreme speed. Various kinds of technical difficulties—such as the electromotive force used, the length of the line and its resistance, and other factors—check the incomparable swiftness of the electric current. As a rule, a message sent over a long wire is slower than one sent by means of electric waves, though the difference, of course, is quite inappreciable in practice—30,000 miles a second is as good as 186,400 miles a second for telegraphic purposes. It is the speed at which the signals can be made by human means, and not the velocity at which they travel through space, which is the thing that counts. Yet Wheatstone's achievement is, in its way, a most remarkable example of the power that the human mind is obtaining over the physical forces of the universe.

AN ANCIENT INDUSTRY OVERLOOKED BY ST. PAUL'S—GLASS-BLOWING IN THE CITY

The glass-works still carried on over the foundations of the Whitefriars Monastery, behind St. Bride's Church, is one of the oldest of London's industries. Over two hundred years ago "all Sorts of Decanthers, Drinking Glasses, Crewits, and also all sorts of common Drinking Glasses," were being made there.

MARVELS OF GLASS-MAKING

Windows Through Which We Gaze on the Inner and Outer Universes

HOW INDUSTRY GIVES EYES TO SCIENCE

ONCE upon a time some Phœnician merchants beached their galley at the mouth of the river Belus, in Palestine, and prepared to cook their meal on the sands. Finding no stones on which to set their cooking-vessel above the fire, they fetched some blocks of natron from the galley for this purpose. When the repast was over, and the fire was cold, they went to take up the blocks of natron, and found that these had melted in the fire, and combined with the fine river-sand to form a strange and wonderful transparent substance. It was thus that the first and most important step in the art of glass-making was discovered by these adventurous merchants from Sidon. For the natron that they used to support their cooking-vessel was an impure form of carbonate of soda, and the fire, blown perhaps to a great intensity by the sea-wind, melted the soda and sand together and produced a glass-like material. The Phœnicians were a very intelligent race; they experimented with the inferior glass they had discovered, and at last found that by adding a certain quantity of manganese they could produce a marvellous material of crystal clearness that could be made into a variety of objects.

Such, according to traditional researches in the matter, was the accidental origin of one of the most wonderful things of human manufacture. In the last twenty-five years so many marvels have been discovered that men have had their sense of wonder dulled by continual excitement. We can now create strange rays that can make many substances transparent to our vision, and we are so proud of these new wonders that we lose sight of equally marvellous things of everyday use that surround us. Yet the discovery of glass is just as extraordinary an achievement of human genius as the discovery of X-rays and radium. When men were able to manufacture in a large way a firm, solid material that was transparent to light, the destinies of the human race were altered. Mankind became possessed of faculties undreamt of by the most imaginative of wizards; for glass was an instrument of tremendous power, that enabled man to open the two gates of infinity—the infinity of the outer universe of space, the infinity of the inner universe of life.

Glass is the tool by means of which man controls light. It enables him to flood his dwelling-place with the cheerful and vital radiance of the sun, placing him beyond the chances of the weather, doubling his powers of work, and keeping down the germs of disease that undermine his health. It is glass that renews his faculty of vision when his eyesight grows dim. It is glass that enables him to construct a multitude of finer and more delicate senses, by which he penetrates to the bounds of the universe, dissolving a flaming star on the confines of space into its original elements, and by which he discovers the secret and invisible forms of life in the dust beneath his feet. And the wonderful pictures that print themselves upon the sensitive plate of a camera are obtained by means of lenses of glass.

Without the chance discovery of the process of glass-making, man could never have grown to his full stature. There would have been no hope of his ever obtaining a large control over the resources of Nature, and establishing on this planet that kingdom of man by means of which, we now all hope, the descendant of the kinsman of the gorilla will one day grow into a truly filial relationship with the divinely creative spirit that is informing this material universe with the aim of controlling it to a higher end. For it is simple truth that glass is the grand foundation of modern science. Lacking it, the human race could have gone

building up civilisation after civilisation; it could have developed its sense of beauty, its sense of religious awe, and its skill in various industries, but it could never have established the solid and deeply laid structure of sheer and far-reaching power over the processes of matter which may one day enable it to comprehend in part the mind of the universe. Science without true religious feeling is power without aim: religion without a large control over natural resources is—if we may express our opinion reverently but frankly—aim without power.

The Time when Glass was Worth Its Weight in Gold

For some thousands of years glass-making was mainly a fine art of an exquisite kind. Even when the Book of Job was written glass was worth its weight in gold; and the Phœnicians seem to have traded glass beads as jewels among the savages of Northern Europe. It used to be thought that the ancient Egyptians, at an early epoch, anticipated the discovery made by the merchants of Sidon, for a drawing of two workmen, apparently engaged in glass-making, has been discovered in a tomb of the eleventh dynasty. But the best authorities now agree that the drawing represents some other process of manufacture. The Sidonians certainly held for a long time the monopoly in glass-making, and they spread the use of the new material throughout the Mediterranean. But gradually a knowledge of the secret of its manufacture extended to Italy, Spain, and Gaul, and the Romans especially became admirable artists in glass.

The famous Portland Vase, that is now one of the chief treasures of the British Museum, is a masterly example of the art of the Roman glass-smith. When Josiah Wedgwood proposed in 1786 to copy it, he came to the conclusion that, even if he could find an artist with the genius necessary to execute such a work, the cost of it would be £5000 at the lowest.

The Roman Cheapening of Glass from Table Use to Window Use

As a matter of fact, wealthy Romans used to pay extraordinary prices even for small glass vases of exquisite workmanship. They were esteemed above vessels of wrought gold. Table-glass of fine and elaborate shape was at first the principal glass industry of the Roman Empire, but mosaic work, made by combining bits of coloured glass into a pictorial design, was soon developed in a variety of beautiful ways.

But the practical Romans at last found the cheaper process of making window-glass; and just as their empire was falling under the attacks of the Northern barbarians, the use of common glass for lighting purposes was extended. A small pane in a bronze frame may be seen at Pompeii, and fragments of window-glass have been picked up from the ruins of Roman villas in England. Glass of this kind was cast on a stone, and was usually very uneven and full of defects; and though it was capable of transmitting light, it must have allowed only an imperfect view of external objects. Very likely this defective method of manufacture was one of the causes why the builders of the early Christian churches adapted the lovelier mosaic work in coloured glass for the purpose of lighting and beautifying their sacred buildings. Thus was evolved the magnificent windows of stained glass that still glow with jewel-like splendour in Chartres Cathedral, showing to what height of beauty the glaziers of the thirteenth century attained.

The Secrets of Glass-Making Dearer to the Venetians than Life

Alongside this lovely development of glass-making, there continued, chiefly in Venice, the more ancient traditions of the art of making exquisite table-glass and other vessels of use and beauty. Like the Sidonians, the glass-makers of Venice carefully guarded the secret processes by means of which they obtained a practical monopoly of fine glass-work. If any workman transported his craft into a foreign country, an emissary was sent by the State to assassinate him. Two men from Murano, the little island at Venice where the glass-makers still live, were induced by the Emperor Leopold to migrate to his dominions, but they were killed by the order of the Council of Ten.

Any artisan caught attempting to go to foreign parts was sent to the galleys. In 1550 eight glass-makers from Murano were engaged by the English Government to found a fine-glass manufactory at Crutchett Friars, in London. But they were so afraid of assassination by the emissaries of the Council of Ten that they tried to run away, and were imprisoned in the Tower, from which place they sent a petition for mercy to the Council. The Government of Venice tried to excuse their policy of maintaining the glass monopoly by murder, by alleging that the workmen who remained at Murano were thrown out of work for two and a half months a year by the spread of glass factories in Spain and Flanders. Undoubtedly, they frightened their migrating artisans sufficiently to conserve the Murano industry

ART'S GREAT TRIUMPH IN GLASSWARE

THE FAMOUS PORTLAND VASE, MADE OF GLASS A THOUSAND YEARS AGO. THE RAISED FIGURES AND DEVICES ARE OF WHITE ENAMEL, AND THE WORKMANSHIP IS GREEK

till the eighteenth century. But their monopoly was broken down by the inventive genius of the Bohemians and the English. The Bohemians discovered a process of producing a very pure crystal, well adapted for engraving, and Prague became the centre of one of the most exquisite of the arts of glass. It eclipsed Venice and dominated Europe.

But by this time several English inventors were working out a new process which was to revolutionise the entire industry of glass-making, and transform what was still a material of art into an instrument of science and a thing of common use. In spite of thousands of years of development, real, good glass is a late invention. The artistic craftsmen of ancient times were unable to make a material free from bubbles and veins of untransparent colour; they could make a beautifully veined vase, though they could not produce a clear sheet of window-glass. This was no doubt one of the reasons why they kept to the artistic side of their craft. It was not until about the middle of the sixteenth century that a good glass mirror, a good pair of spectacles, or a fairly good lens for a telescope could be made; and even then the new products were very costly.

The Incomparable Flint Glass of England that Gave New Powers to Science

All this was altered by Sir William Slingsby, Sir Jerome Bowes, and Sir Robert Mansel between 1610 and 1616. Coal was then coming into general use in England, and these inventors began with the idea of using the new fuel in glass-making. Up to their time, glass had been made by placing the various materials in an open pot, and fusing them with a wood fire. In using coal, however, it was necessary to close the pots at the top, but the English inventors found that this had the effect of seriously diminishing the amount of heat that played on the materials. They therefore increased at first the proportion of the most fusible element used in glass-making. This was then potash, obtained by burning seaweed. It was found, however, that the increased amount of potash injured the colour and the quality of the glass; and at last oxide of lead was tried with the happiest of results.

For the new glass—now famous all the world over as English flint glass—was the most beautiful glassy substance that human skill could make. Nothing produced in Venice or Prague could remotely approach it. In brilliancy, weight, density, and crystal clearness, it was incomparable; and upon it there was built up in England an industry of the highest importance for science as well as for glass craftsmanship and for general lighting purposes.

It was by means of a prism of flint glass that Newton broke up the white sunlight into a band of colours, and so laid the foundation of all the methods of spectrum analysis by means of which the elements burning in the remotest star can be distinguished as easily as the substances used in modern industries. It was by means of flint glass that the English lens-makers made telescopes and microscopes, and gave men of science an enormous extension of the power needed in the finest and grandest of researches into the mysteries of Nature.

The Combination of Exquisite Beauty with Use that Followed the Flint Process

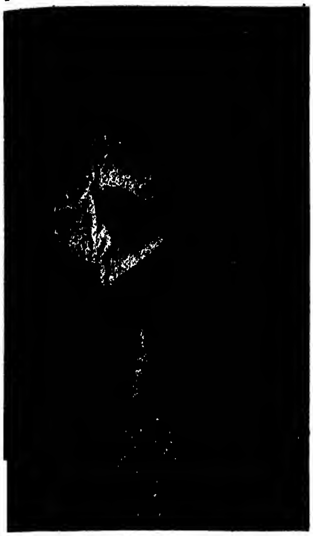
The discovery of flint glass also contributed largely to the conveniences of human life, by bringing the price of good window-glass within the reach of everybody, and by cheapening mirrors and every kind of glassware. It is only recently that the simple but exquisite beauty of English table-glass of the eighteenth century has been appreciated; yet it was so good that even the Bohemian glass-makers felt they could not compete with it, and, giving over the fabrication of their own special ware, they devoted themselves to the making of objects in coloured glass.

In practically every field of manufacture in which glass of the finest quality was required, the English glass-maker became supreme. He helped to make the English lighthouse the best guide to the mariner; and if there was more light in English towns at night than there was in foreign cities, it was because of the excellence and cheapness of the glass that he made for lanterns. In short, the invention of flint glass by means of a coal furnace and a closed pot, in which lead was used, was the most important step in the manufacture of a generally useful transparent material, since the far-off days when a Phœnician galley was beached on the sands of Syria.

The German Lead in Making Jena Glass for Optical Purposes

Scarcely any other advance of high moment was made in the glass industry until two German men of science, Schott and Abbé, took up the scientific study of glass in the latter part of the nineteenth century. They wanted new transparent materials for microscopic work, and, helped by subsidies from the German Government, they conducted a splendid series of researches into the making of glass, that

HOW A FRAGILE WINE GLASS IS SHAPED

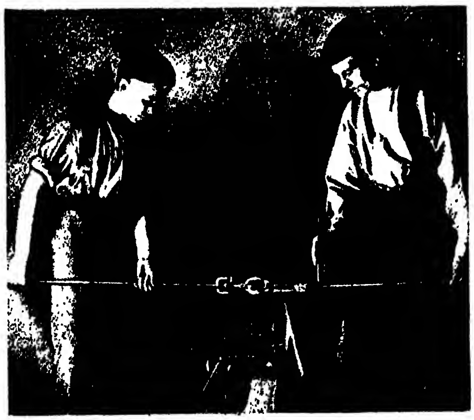


The blower first collects some molten glass from the furnace on to the end of his pipe.

By blowing through the pipe he forces the soft glass into the form of a big bubble.

He next moulds this big bubble into the smooth bowl by rolling it upon an iron table.

He then casts on sufficient molten metal to form the stem, which he fashions with iron tools, and afterwards adds the foot similarly.



The workman next marks a circle round the bowl with moistened iron pincers and breaks free the glass by a smart tap on his pipe.

The top of the glass is well heated in the furnace, and is sheared to the required height.

The glass is now carefully removed from its holder and taken to the annealing oven, where it is cooled very gradually to obviate brittleness.

resulted in the creation of the now famous Jena glass. They discovered, for instance, the barium glass which combines the superb optical qualities of flint glass with the useful properties of ordinary crown glass. It would take us too far into the subject of lens construction to explain at length the possibilities opened up to the optician by the invention of the newer varieties of glass. But one of the consequences of the work of Schott and Abbé was that Germany became for a while supreme in the manufacture of the best kinds of scientific instruments in which glass plays an important part.

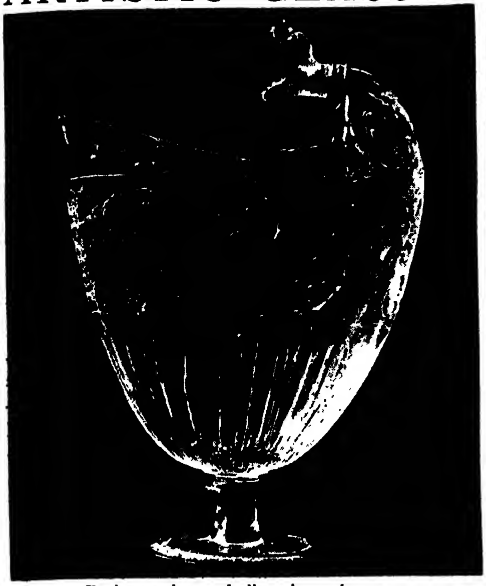
It is only in the last few years that English lens-makers have been able to produce microscopes and other instruments of research with some qualities superior to those of German make. The finest microscope objectives, the finest photographic lenses, and the best telescope glasses are all based upon the German invention of Jena glass. And though at the present time glasses of the newer types are produced in French and English manufactories in quantity and quality at least equal to the output of the Jena works themselves, these great optical achievements stand as a lasting monument of the pioneer work of Schott and Abbé.

WORK AT A MEDIÆVAL GLASS FACTORY
From a Flemish manuscript of the late fifteenth century

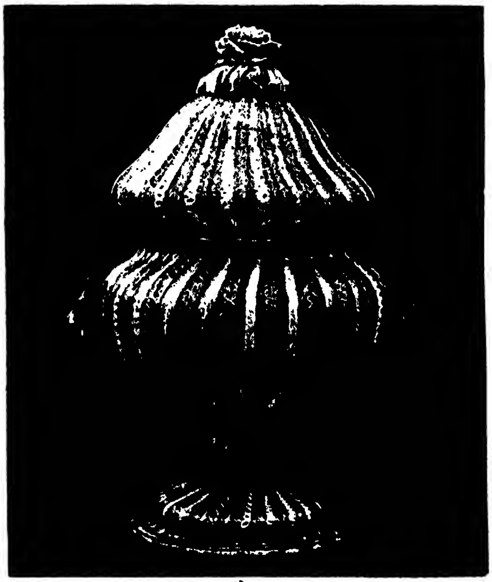
As a matter of fact, these two remarkable men arrived at their discoveries by quite primitive methods. They merely tried everything likely to make a useful ingredient in a glass mixture, until they obtained the kind of transparency which they needed. They were compelled to use the ancient method of trial and error, or rule of thumb. For too little is yet known about the scientific aspects of glass-making to enable a more foreseeing process of research to be usefully employed. Men of science, indeed, are not yet agreed upon the fundamental problems of glass-making. Glass is still an unknown world, and its nature and its constitution have yet to be discovered. So it is regarded at present as a structureless solid, with the same lack of arrangement in the grouping of its molecules as is found in water.

It is a congealed liquid, in which the process of congealing involves no change of structure, but merely brings about a gradual stiffening of the liquid until it behaves like a solid. And the strange thing is that the ingredients out of which glass is made are not reduced to their liquid or molten state of combination simply by heat. It is the chemical dissolving action that they produce on each other which is the main factor. In, for instance, an ordinary English process of glass-making, suitable proportions of sand, carbonate of lime, and carbonate of soda are mixed together by machinery, and shut into a vessel of fireclay enclosed in a gas furnace. The heat of the furnace first sets the mixture working. For by the mere action of the heat the carbonate of soda melts, and the carbonate of lime loses its carbonic acid, and is burnt into caustic lime. Thus is produced a mass consisting of grains of sand and grains of decomposing carbonate of lime, all cemented together by the melted soda. By this time, however, the sand acquires a strong acid action; it attacks the carbonate of lime, and, moreover, does more than the heat of the furnace can by attacking and decomposing the carbonate of soda. The final result is the complete expulsion of all carbonic acid, and the formation of compounds of lime and sand

ARTISTIC GLASSWARE OF 1000 YEARS



Rock crystal ewer, Italian, sixteenth century

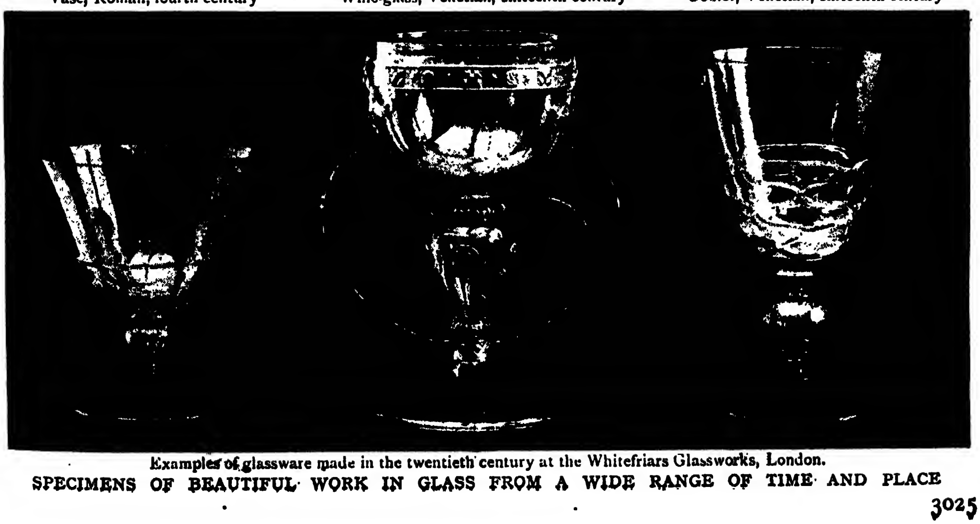


Glass bowl with cover, Venetian, sixteenth century

Vase, Roman, fourth century

Wine-glass, Venetian, sixteenth century

Goblet, Venetian, sixteenth century



Examples of glassware made in the twentieth century at the Whitefriars Glassworks, London.

SPECIMENS OF BEAUTIFUL WORK IN GLASS FROM A WIDE RANGE OF TIME AND PLACE

and soda and sand, which remain in the finished glass in a condition partly of mutual chemical combination and partly of mutual solution.

Where salt-cake is used to make glass, neither the action of the heat nor the dissolving power of the sand is sufficient to bring about the rapid decomposition of the soda. So carbon has to be introduced in the form of coke or charcoal or anthracite coal, and this supply, assisted by the carbon already in the gases of the furnace, produces the desired effect.

The Original Glass Made by Nature Herself in Volcanic Processes

It may not be generally known that one very curious kind of glass is sometimes manufactured by purely natural forces. This takes place in a volcanic eruption, in favourable circumstances, where the intense heat sets up chemical actions on various substances, that fuse together into an impure, semi-transparent glass known as obsidian. It varies in colour from grey to black, and has been used in making works of art by the Egyptians, Romans, and Mexicans.

So what we do in a glass-furnace, after all, is merely to imitate some of the chance processes of volcanic action. But by selecting our materials, and using them in proportions that do not occur in Nature, we produce something that conduces in a remarkable degree to progress in knowledge and art, in health and comfort and luxury. The vitriable element in glass is practically always sand. The purest sand used only to be obtained from a deposit at Fontainebleau, near Paris, but an equally good material is now found at Lippe, in Germany. No sand comparable to these two has been discovered and worked in Great Britain. Next in order of value to these exceedingly pure silicas come the glass-making sands of Belgium, that contain a little iron and aluminia. They are used very largely for the manufacture of sheet and plate glass.

The Chemical Ingredients of Different Kinds of Glass

When the standard of quality is further relaxed, a great number of sand deposits become available; and the manufacturers of each district rely on more or less local supplies. In England, the sands of Leighton, in Bedfordshire, and of Lynn, on the East Coast, are largely employed. Finally, for the manufacture of the cheapest class of bottles, sands containing considerable traces of iron and other substances are often used. Our old flint glass used to be made by grinding flints to powder; and sandstone and certain other rocks are still sometimes treated in this manner. But crushing stone is an expensive and difficult process, and in practice only certain kinds of felspar are widely used instead of sand. Their value is due to the fact that they not only contain the acid but also the alkali necessary in glass-making.

More usually, however, the alkali is obtained in a separate form from the acid of the sand. Various alkalis, such as carbonate of soda and sulphate of soda, are produced in the famous English alkali-works, which have almost a universal monopoly in the manufacture of these chemicals. The Germans, on the other hand, have a similar monopoly of the potash industry; and, having swept the old seaweed burners out of existence, they supply most of the potash used in making potash glasses. Recently, however, millions of tons of potash have been discovered in the Mojave Desert, in Western America; and the Americans, who recently made their quarrel with the German Potash Trust a serious international affair, now seem to be arriving at a position in which they will be able to fight their old enemies in all the markets of the world.

How Primitive Methods Hold Their Own in the Finest Glass-Work

In addition to the alkali basis of glass, there is a considerable number of other substances that are largely employed. For instance, lime is used for the production of all varieties of plate and sheet glass, as well as for bottles and certain kinds of pressed glass and blown glass. And, as we have already seen, the famous flint glass of England is based upon lead. In Jena glass, a preparation of the silver-like metal of barium, discovered by Sir Humphry Davy, is of importance, and zinc and magnesia and aluminium are used in the manufacture of special glasses for scientific purposes, where special properties are required. By using an electric furnace or an intense oxygen flame, quartz is now melted down into a valuable glass. Unlike ordinary kinds of glass, the fused quartz is transparent to the invisible ultra-violet rays of light, and it is largely coming into use for scientific purposes, and for the medical treatment of certain diseases.

In recent years the ancient craft of the glass-blower has been transformed to a considerable extent into a factory process by the use of ingenious machines and metal moulds into which the molten glass is

driven by steam or compressed air. But in the production of the finest optical glass the method of manufacture remains strangely primitive. A single pot of fireclay is built into a furnace heated by coal or gas. When the pot is red-hot, the raw material is slowly shovelled in small quantities into its mouth, and it is ten hours after the last charge has been added that the furnace is driven to its highest temperature. It is kept at this temperature for twenty hours, and then the molten glass is stirred for another fifteen hours or more. This is done by means of a rod of fireclay, balanced on an iron beam above the furnace, with a wooden handle moved by a workman clad in an asbestos dress.

The heat is terrific, but the stirrer must not relax his efforts for a minute. The work is so trying and arduous that it has to be performed in short shifts. On it depends the ultimate success of the operation. The constant and prolonged stirring is necessary to remove from the glass the transparent threads and veins which are invariably found in ordinary glass. For the different ingredients have a tendency to separate, and rise or sink in the pot, according to their comparative lightness or weight. It is this process of separation that produces the common defects of glass, and it is only partly prevented by keeping the whole molten mass of the bath is a state of gentle but continual agitation. While the stirring goes on, the temperature of the furnace is allowed to diminish. The result is that the fluid gradually stiffens, until the fireclay rod can only be moved with great difficulty. The rod is then removed, and the furnace allowed to cool for another five hours.

The cooling is stopped, and the whole furnace is sealed up with brickwork and fireclay, and the glass is left to anneal gradually for one or two weeks. The pot is then drawn out, usually in a cracked condition, and is broken away by the aid of a hammer. In especially favourable circumstances, the whole of the glass may have cooled into a solid lump, but it is more usual to find it broken into fragments. These are picked over, and the pieces that are found to be absolutely clear are used in making the finest kind of lens. The famous American observatory on Mount Wilson has been waiting for years for its last telescopic glass, measuring a hundred inches across, and weighing four and a half tons. The money has long since been provided for the glass, but several attempts have been vainly made to cast it. Men of science of great ability have travelled from America to France to help the glass-maker in his extraordinary task, but, as far as we know, the immense disc has not yet been made.

CASTING A LARGE TELESCOPE LENS AT JENA

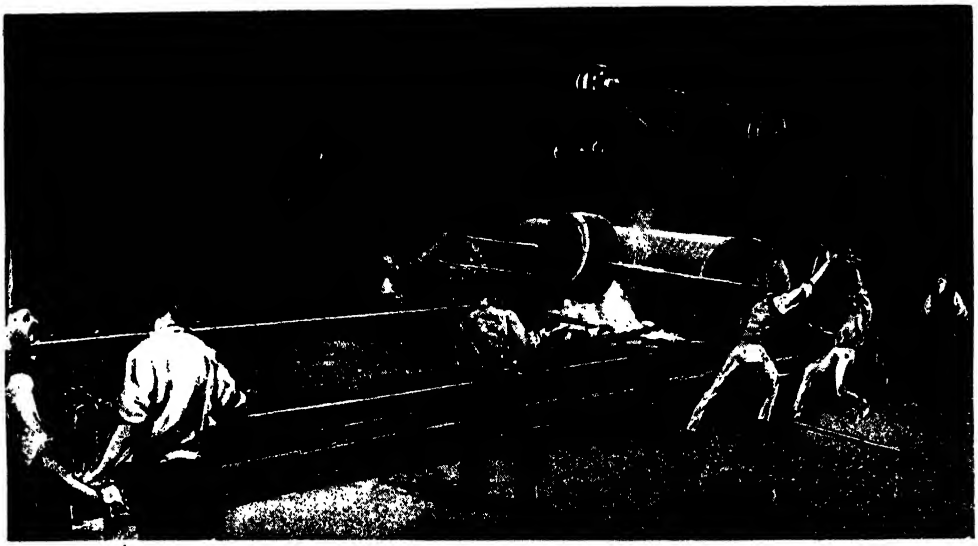
At the other extreme of the glass industry is a huge tank furnace, heated by producer gas, which turns out with punctual regularity the material from which bottles are shaped by machinery in millions every year. The tank is built of large blocks of fireclay, in the shape of an oblong basin, over which plays an intense flame of aerated gas. The raw materials are thrown into the furnace at the square end of the tank, and the gas flows uninterruptedly down the furnace to the colder semi-circular end of the tank that is pierced with working holes.

The workman thrusts an iron rod through one of these holes, and twirls around it a charge of the sticky fluid, which he drops into the machine. The liquid glass flows into a mould, from which it receives the shape of the neck of a bottle; and while it

still retains its liquidity, a plunger makes a hole through it, and a stream of compressed air sweeps into this hole and blows the glass out, shaping the shoulder of the bottle. The glass is now growing decidedly stiff, and it passes into a finishing mould, where it is blown by powerful air pressure into its final shape, though in some cases another machine is needed to form the indentation at the base. By pressing a lever the workman then releases all the moulds, thus leaving the bottle completely finished and entirely free. Two men and a boy work the whole machinery: one man gathers the glass from the tank, another works the levers that bring the moulds into action, and the boy carries the finished bottles to a kiln where they are annealed by passing on trucks down a tunnel that is hot at one end and cold at the other.

The tank furnace is also used for making plate glass. It is by no means uncommon for a single furnace to have a weekly output of a hundred and fifty tons of British glass. The glass is withdrawn from the furnace by means of huge iron ladles, holding two hundred pounds of burning fluid, and carried by slings attached to trolleys running on an overhead rail. But a workman, covered in thick felt, with his face protected by a mask, in which there are eyeholes glazed with green glass, has to guide the ladle to the tank, and twist it into the fiercely hot molten glass. He then jerks off the threads and sheets of stiffening fluid that hang to it, and attaches the handle of the ladle to the overhead trolley. He next has to bear all his weight on the handle, to draw the whole ladle up from the molten bath in the furnace and out through the working hole in the tank. The operation only takes a few seconds to perform, but while it lasts the ladler is exposed to terrible heat, as an intense flame shoots through the working hole and curls up under the hood of the furnace.

Aided by a boy, the ladler then runs the charge of glass to an iron table, and there he empties out the molten liquid in front of a massive iron roller. Impelled by steam power, the roller passes over the glass, flattening it into a soft, red-hot sheet that has to remain on the iron table to cool and harden before it can be safely removed. The sheet is then taken on a stone slab into a long, low tunnel, hot at one end and cold at the other, and down this tunnel it very slowly passes, cooling and annealing, ready for cutting in the cutting-room.

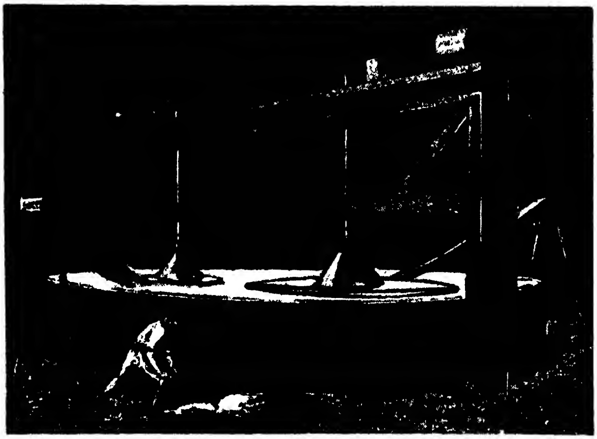


POURING THE MOLTEN METAL ON THE CASTING-TABLE IN A PLATE-GLASS WORKS

Ordinary sheet glass is also made in a tank furnace. Sometimes three independent furnaces are connected with each other by small openings through which the fused materials flow, refining as they flow. By this means a finer glass is produced, which has many of the properties of polished plate glass. The process of making sheet glass is very interesting. It is done by three groups of workmen—the pipe-warmers, the gatherers, and the blowers. The pipe-warmer heats a blowing-pipe, formed of an iron tube, about four and a half feet long, provided at one end with a wooden handle and a mouthpiece, and at the other end

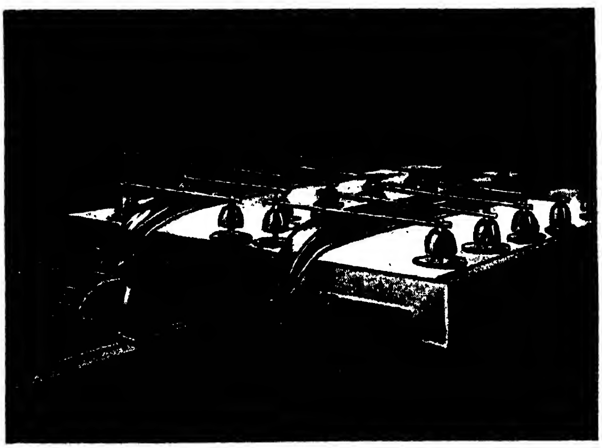
with a thick cone. After heating the pipe, the warmer blows through it, to see that the passage is clear, and then places the thick end in the tank of glass. Then the gatherer intervenes. With a knack born of long experience, he collects a quantity of glass round the butt-end of the pipe, by twisting it slowly in the molten fluid.

Cooling his first gathering, the gatherer dips the pipe in again and collects more glass, doing this with a skill that prevents any air-bubbles forming between the cool glass and the fresh gathering. The pipe is then rotated across an iron trough filled with water. This helps to cool the pipe itself and stiffen the glass; and again the gatherer takes the pipe to the tank and collects more of the molten fluid. In some places the process is repeated five times; and the care and skill with which the operations of gathering are carried out largely determine the quality of the glass. Any want of regularity in the shape of the gatherings inevitably leads to variations of thickness in different parts of the sheet, while a careless gatherer introduces bubbles and other markings in the finished product. When the gatherings have been well done, the cooling glass forms a round mass, with the nose end of the pipe at its centre. By means of special shaping instruments the glass is then moulded into a sort of bottle, the neck of which fits over the nose of the blowpipe.



ROUGH-GRINDING PLATE GLASS ON A ROTATING TABLE

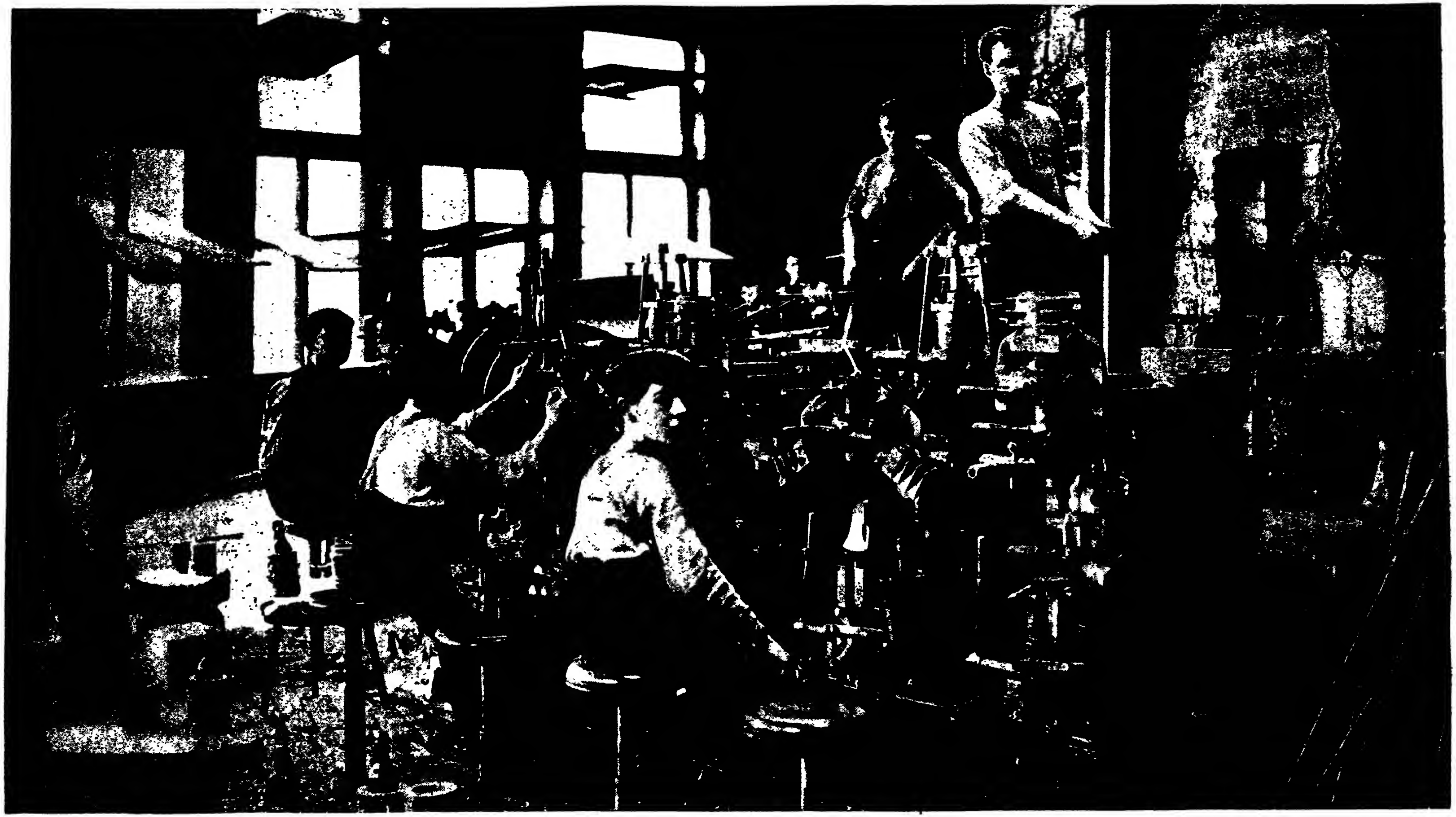
At this point the blower begins his work. He works on a stage, with some small furnaces, called blowing-holes, in front of him, or sometimes the stage is erected against the main melting furnace. It is simply a platform placed over a pit, called the blower's pit. The glass-maker first heats the bulb of glass in one of the blowing-holes, and then swings the pipe with a pendulum movement in the pit. Purely by its own weight, the half-remelted glass cylinder at the end of the pipe begins to elongate itself. Any tendency to collapse is checked by the blower blowing with his mouth through the pipe, which he also at times rotates. The operation of heating and lengthening the cylinder is repeated until the glass is equally distributed on all sides, forming a long tube, hanging by a thin neck from the blowpipe and closed at the lower end with a rounded dome. This rounded end is then opened by heating it till it is soft enough for a circle to be cut out with a pair of shears. Again the glass is heated, and hung downwards in the pit and twisted rapidly by the blower. The soft glass at the lower end immediately opens out under the whirling action, which the blower continues until the soft end straightens out in agreement with the rest of the glass tube.



POLISHING PLATE GLASS WITH FELT-COVERED DISCS

When cooled and broken from the blowpipe, the tube is split open by a hot iron or a diamond. It is then placed on a smooth slab in a hot kiln, where it grows soft enough to be flattened out on the slab by means of a wooden tool. Then, like other

THE SUPERSEDING OF HANDWORK BY MACHINERY—MOULDS FOR MAKING GLASS BOTTLES



ONE MACHINE WILL WORK BY COMPRESSED AIR SEVERAL MOULDS, WHICH FINISH COMPLETELY ALL THE PARTS OF THE BOTTLE, READY FOR ANNEALING

ordinary glasses, it is moved through a long tunnel, and annealed by being exposed to a change of temperature from hot to cold. It will be thus seen that the usual manufacture of sheet glass is a long, complicated, and laborious process, needing workmen of high skill. Various machines have recently been invented to do the work and cheapen the cost of the glass, but none of them is yet as perfect in achievement as are the hands of the gatherer and the blower.

In the finest kinds of sheet glass, the tank furnace is not used. The ingredients are put into pots, and a number of these are set in what is called a pot furnace, and exposed to the flame of aerated gas. The method is more costly than that of the tank furnace; the fuel consumption is greater, and the output smaller. On the other hand, the composition of glass can be more accurately calculated in a pot furnace than in a tank furnace, as the molten fluid is better protected from contamination by the furnace gases or dropping matter. It is also possible to melt thoroughly in pots materials which could not be got to combine in the open basin of a tank. In flint glass especially the molten material must be put in a closed pot, to protect it from the reducing action of the furnace gases. So all the best hollow glassware is in many ways costlier to manufacture than tank-fused glass. A good deal of hollow glassware, however, has been cheapened by means of machines in which moulds are used. A lamp chimney, for instance, is made in the same way as the bottle, being blown in a mould with a flat bottom and a domed top, both of which are subsequently cut off. Moulds are also employed in making electric light bulbs, and many of the cheaper kinds of tumblers and glasses.

ENGRAVING A TUMBLER BY MEANS OF A COPPER WHEEL AND EMERY-POWDER

Yet the old-fashioned glass-blower still produces the finest varieties of hollow glassware. At his best he is a craftsman of the old school, with a true feeling for the artistic qualities of his material. His implements are few and simple. He sits on a rough wooden bench, on which there are two projecting side-rails. On these rails he rolls his pipe, and close to him on the bench is a small rod and some shears and pincers, together with a flat board and a small slab of stone or metal. Gathering some melted glass on his pipe, he blows it into a small bulb, and lengthens the bulb by gently swinging it at the end of the pipe. Having obtained the shape he wants, he presses the bulb on the stone slab, and so gives it a flat bottom. He then breaks the bulb off the pipe by means of a hot wire, and sends the article to be annealed by gradual chilling. The rough edge is afterwards rounded off by the aid of a blowpipe flame, and a glass tumbler of perfect shape is ready for use.

Such is one of the simplest examples of the glass-blower's craft. For more artistic work he makes use of the pasty qualities of cooling glass. By raising or lowering the temperature of his material, he makes it now stiffer and now more fluid. He distends it by blowing, or he draws it out by swinging his pipe, and moulds it with the aid of rods and tongs; or he holds it aloft and lets it fall in festoons under its own weight. With all these manipulations at his disposal, the glass-blower of the old school works the glass to his will, and fashions it into objects of great variety and beauty. Everything that he makes is original, having little of the regularity of size and shape of machine-made articles. For there is a natural variability in the curves and festoons made by the glass blower, so that it is impossible for him, in his best work, ever to repeat himself.

In the machine work that now competes with the beautiful things made by the glass-blower, two different methods are used. In one, the glass is blown by compressed air into the various moulds; in the other the material is pressed into shape by means of a mechanical plunger. The articles

moulded in these two ways, however, lack the fine fire-polish possessed by glass that is allowed to cool freely from the molten state. An attempt to produce a similar brilliance of surface on moulded and pressed wares is often made by exposing them, in their finished form, to the heat of a furnace. This softens the surfaces and gives them a new brilliancy. But as the process cannot be carried out without softening the entire article, great skill is required to prevent serious deformation, and all sharp corners and angles tend to be melted and rounded off. Imitation cut glass is easily detected by the blunting effect of angles and corners produced during the reheating process.

Moulded articles can also be distinguished by the slight projections caused by the pressed glass getting in the fine interstices between the various parts of the hinged moulds. Probably it is in order to hide these defects that so much machine-made glass is grossly over-decorated with grooves and spirals and ribbings. Simplicity of design, exquisiteness of proportion, with, perhaps, just a graceful touch of ornament, are the qualities that an enlightened manufacturer of table-glass and other hollow wares should aim at. By so doing he would establish his business on a firm and enlarging basis. For it is clearly evident that the general taste is improving. This is clearly seen in the designs of modern furniture.

POLISHING A LARGE CUT-GLASS BOWL ON A WOODEN WHEEL

All round we are breaking away from the amazingly bad ideas of design of our grandfathers, and returning to the fine simplicity which all our craftsmen of the eighteenth century practised. There is no reason why even a machine-made piece of glass should not be a thing of beauty as well as of utility. The cost of design is an exceedingly small item in the general expense of the mauufacture; and the great glass-making firms that quickly grasp this simple truth will steadily get much of the best trade in their hands. Certainly machine-made glassware is one of the luxuries of modern civilisation that are almost necessities. Production must be cheapened to bring the most fragile and not the least useful of articles well within the reach of our huge working population. But there is no real relation between cheapness and tastelessness.

At present, the wonderful colour resources of the glass-maker are, in a great many cases hopelessly misapplied. But in the hands of a fine designer few other materials are capable of yielding results equal in beauty to that of coloured glass. Many of the colouring agents are cheap, as only a minute quantity is needed to produce lovely delicate, and jewel-like tints. Indeed, the sole difficulty involved in the use of several important colouring substances is that so little of them is needed that it is hard to weigh exactly the amount that is required. The range of colours is practically unlimited, particularly as the colouring elements can be employed in almost any combination to produce exquisitely graduated tints. Even stained glass-work of the finest quality is no longer a lost art. Modern craftsmen have at their disposal materials quite as excellent as those employed in the thirteenth century.

The jewel-like splendour of the best ancient glass was för many years unattainable, owing to a curious cause. Modern glass was too good for the purpose. It was so transparent that the light passed through it, instead of bringing out the interest and mystery of the glass itself. It was found that the ancient stained glass was very badly made, with an irregular surface and an extraordinary number of internal defects—airbells, veins and even bits of foreign matter. But these things scattered and twisted and reflected back the light, until the rays appeared to emanate from the body of the glass itself, which thus seemed to shine with an internal light of its own. So, by having his glass made very badly, the modern worker in stained glass has been able to equal the lovely effects of the ancient masters of his craft.

WEALTH AND WELL-BEING

The True Nature of Wealth, and the End and Aim of Human Effort in Trade and Industry

VALUE OF BRITISH ACCUMULATIONS

The aim of commerce is to increase wealth, and probably everyone thinks, in the words of John Stuart Mill, that he "has a notion, sufficiently correct for common purposes, of what is meant by wealth." As is often the case when commonly used terms come to be analysed, however, wealth is a thing exceedingly difficult to define. Want of clear thinking upon the subject long hampered and impeded the efforts of civilised countries to become wealthy. The use of money as a medium of exchange, and the obvious suitability of the precious metals for the purposes of money, led to the fallacious belief, entertained for centuries, and even in some quarters surviving to this day, that wealth solely consists of the precious metals, or of "money." So firmly was this belief held that the trade policy of many countries came to be based upon it, to their grievous hurt.

It was thought that if a country had gold and silver mines it was a naturally wealthy country, and that its chief object should be to retain its gold and silver within its borders. On the other hand, if a country lacked gold and silver of its own, its main object was held to be to get as much as possible of the precious metals from other countries and to keep it. That is why it was that the ancient idea of colonisation was such a complete failure. The Spanish adventurers who discovered the New World looked upon it as a happy hunting-ground for gold and silver. They passed by the real wealth of the countries they ravaged in pursuit of Eldorados.

Commerce was infected by the same idea. It was thought that the sole end and aim of foreign trade was to export goods to other countries, and to obtain payment in gold and silver, thus adding to the wealth of the nation. Conversely, it was thought that it was ruinous to import, because, as payment had to be made in money, wealth was accordingly lost. This theory of trade, known as the Mercantile Theory, had for its golden rule that the more largely exports exceeded imports, the better for a country, since the balance represented gain in money. The idea of trade as a matter of mutual benefit had not been conceived; the notion was that commerce was a struggle between the nations of the world to win as much gold as possible.

It is quite easy to see how these absurd ideas came to have such a hold, not only on the popular mind, but even upon statesmen. We commonly talk of wealth in terms of money. We say that So-and-So is worth a million of money, or that a rich man has "plenty of money." What we really mean is that a millionaire possesses property which is worth so much, measured by the definite amount of gold which we call a sovereign; we do not mean that he possesses a million sovereigns. It is true that a single millionaire, who cared to sell out all his possessions, could change them into gold, and actually come to possess a million golden sovereigns, but if all our millionaires tried to do so they would fail, for there is only about £100,000,000 or so of gold in the United Kingdom. The accumulated wealth of the United Kingdom probably amounts to as much as £14,000,000,000. or more, as we shall see presently, but all that that means is that, measured in terms of the sovereign, the actual capital has the exchange value of 14,000,000,000 sovereigns, not that 14,000,000,000 sovereigns actually exist.

Indeed, if the £14,000,000,000 worth of property were suddenly changed into sovereigns we should be poorer and not richer. We should perish, for gold is intrinsically one of the least useful of metals. All we want of gold is a very small amount for

ornamental purposes, and a larger but by no means enormous quantity for currency purposes to facilitate the exchange of commodities. What we require in wealth are a thousand and one useful and pleasurable commodities to sustain our lives in health, comfort, and happiness. The truth about the precious metals is that while gold and silver are particular instances of wealth, they do not solely constitute wealth, but, themselves forms of wealth, are a convenient means of measuring all wealth as standards of value.

The word "wealth" has an interesting etymology. The Anglo-Saxon "wela" meant "well-being," and gave rise to the Middle English "welthe," and later to our "wealth." There can be no question that well-being—individual, social, and national well-being—should be the supreme aim of all human activity, and that "wealth" and "well-being" should always express the same idea. Economics, the science of wealth (etymologically, the science of house-law or husbandry), has to take account of the fact, and the modern economist avoids many ancient errors by constantly reminding himself of it. By the teaching of economists, wealth consists of all things that satisfy wants (*i.e.*, that possess utility), which can be transferred or exchanged, and which, because they are limited in supply, have value in exchange.

Proofs that Utility Alone is Not a Criterion of Wealth

If we take the first parts of this definition alone, we have a statement which is true but incomplete. All wealth consists of more or less desirable things which satisfy some want or need, but, on the other hand, it is not everything which supplies a want which can be called wealth. Air, for example, is a prime necessity of human existence, but it is not wealth, because under ordinary circumstances it is procurable in unlimited quantities by everyone. While invaluable to the human economy it has no value in exchange. Thus also it is with water in a well-watered land with a sparse population. We see clearly that utility alone, however great, is not a criterion of wealth in the economic sense. Indeed, we may have the curious paradox that the pursuit of wealth in the economic sense may deprive us of invaluable non-exchangeable utilities, and therefore of well-being. For example, a clerk, finding it necessary to earn wages, may hire himself out to work under conditions in which, through lack of a non-transferable or non-exchangeable commodity—fresh air—he may lose his health. Here in the effort of obtaining economic wealth he loses something which cannot be classed as wealth, but yet is more indispensable than any other thing.

Thus also it is with another prime necessity of human existence—free access to sunshine. Sunlight is not wealth, and yet it is beyond price. It satisfies a great want, but it is in ordinary circumstances unlimited in supply and without value in exchange. In pursuit of those exchangeable goods of limited supply which are wealth by our definition, millions of men place themselves under conditions in which, from lack of sunshine, they lose health, strength, and even life itself.

The Danger of Setting the Value of Economic Wealth Above that of Well-Being

Thus a nation possessing economic wealth may easily lose a great part of its vitality if it sets the pursuit of economic wealth above the pursuit of well-being. It was the ignoring of this all-important fact by the economists of their day which earned the scorn of Carlyle and Ruskin. In "Unto This Last," Ruskin wrote, in 1862: "There is no wealth but life. Life, including all its powers of love, of joy, and of admiration. That country is the richest which nourishes the greatest number of noble and happy human beings; that man is richest who, having perfected the functions of his own life to the utmost, has also the widest helpful influence, both personal and by means of his possessions, over the lives of others."

Life, "with all its powers of love, of joy, and of admiration," is not wealth within our definition; and it is because economic wealth is capable of destroying life as well as of sustaining it that individuals and nations cannot entirely guide themselves by the principles of the old economists.

The True Test of Wealth—Utility and the Promotion of Social Well-Being

If we desired to make a definition of wealth coincide with a proper conception of well-being, we should make it read: Wealth consists of all things that satisfy wants (*i.e.*, that possess utility), which can be transferred or exchanged, which because they are limited in supply have value in exchange, ***and which promote individual and social well-being.***

From the beginning the life of mankind has been a pursuit of wealth or what is esteemed for wealth. The primitive man was compelled to a ceaseless struggle for a bare existence. Land was his in plenty, but Nature, as yet uncontrolled and untamed,

yielded little to his strivings, and in the struggle for what little she afforded the savage had to fight hard with his fellows. The ascent to tools, to cultivation, to domestication of animals, to ordered communities, was a slow and painful one; and it was long before any considerable number of men won, either through the voluntary service of their fellows or through the institution of slavery, freedom from hard and bitter toil. As the production of wealth was made easier, and the standard of life rose higher, the pursuit of wealth became no less ardent.

The Expansion of the Desire for Wealth with the Growth of Man's Needs

Each increase in the standard of living creates new wants in us. Our wants and supposed needs are regulated by custom, and we are not content with less than we know of as desirable things. Man's wants are thus indefinite, and it is impossible to put bounds to his desire for wealth. This is as true of the moral as of the selfish. The latter desires infinite command of wealth for himself; the former desires the indefinite command of the means of life by the multitude.

The ascent of man does not, therefore, free him from the necessity of labour or the pursuit of wealth. It may, however, eventually free him from unremitting labour; it may confer upon all men the enjoyment of a high standard of life, in which there shall be considerable elements of freedom and leisure.

We all know that labour varies greatly in character, that some tasks are agreeable and others irksome and monotonous. It is not the distinction between mental and manual labour which we refer to. Either mental or manual tasks may be laborious; either, again, may be stimulating and agreeable. It is a physical effort to climb a mountain, but the thing is often done for sheer joy of conquering a physical difficulty and triumphing over natural obstacles.

The Pursuit of Wealth in Relation to Irksome Labours

Many manual tasks calling for considerable physical effort, such as gardening or joinery, are often taken up as hobbies by leisured persons. The truth is that labour is irksome when it is pursued without variety for long hours, when little of skill is exercised in its performance, when it is exceedingly laborious, or when it brings little of reward.

Modern society has made us accustomed to the use of, or desire for, a multitude of complex articles. Our houses, our clothing, our every appurtenance of pleasure or sport, call for a huge variety of articles which, if made pleasurably by individuals, would take so long to make that few of them would be available. We solve the problem of producing a large output of labour by machine production. As a result, manufacturing work becomes irksome in the extreme. To make a boot entirely by hand was a task which yielded variety and pleasure in labour. Not so with the modern boot factory. Boots are now produced by complicated machines, and each individual part of a boot is made by a separate machine. Consequently, the worker told off to mind the separate machine does nothing all day long but one wearisome, mind-destroying task. Hour after hour, day after day, week after week, year after year, he is found fastening heels, or holding up boots to the lasting-machine. The machine itself is a great triumph of the human intellect; in the working of the machine is involved the degradation of labour.

The Irksomeness of Mechanical Labour Paid for by Greater Leisure

At first sight it would appear that labour has been permanently degraded by the rise of the factory system and the march of the machine. Clearly, we should not be content to go back to that simple primitive life which calls for a minimum of effort because wants are few and little of material goods is needed to supply them. How, then, is labour to escape from the irksome consequences of supplying by machinery the complicated and extensive needs of modern mankind? The answer to this question may happily be found in the perfecting of the organisation of mankind for the labour which has to be done, and the consequent winning of leisure.

This hope becomes eminently reasonable when we consider the extraordinary capacity for rapid production which has already been won. We have referred to the boot manufacture. A visit to a modern boot factory shows that the entire work of making a boot—the addition of the few moments with which each of the many machines is concerned with a particular pair of boots—is very little. Similarly, if we go to a cycle factory, we find that the aggregate of the labour now needed to produce a cycle is ridiculously small. Consideration shows that machine power is so great that, although its individual processes are necessarily monotonous, the proper organisation of the working members of the

community would suffice to get done all work of the kind that needs doing in a very short space of time. We see our way to the possibility, through machine production, of working days so short as to give to the machine-minder a large leisure in which to develop his many-sided powers. We see our way to the universal distribution of leisure.

Indeed, already a considerable shortening of hours has marked the progress of machine manufacture, and an eight-hours day rules in the coal-mines of Britain and Germany. Eight hours are now worked in many a trade where a twelve-hour day once obtained. There is no good reason why, with the efflux of time, any man or woman should work at tedious processes for more than a four or five hours day, or why that short working-time should not produce a plentiful supply of commodities. It will be apparent that such a consummation would change the entire outlook of labour, and relieve every task of its irksomeness. We have to aim at a system in which a man shall understand the necessity of work, shall feel that his work is wisely organised and economically exerted, and shall know that it brings him ample leisure and remuneration. The thing is possible, and because it is possible the future of work is full of hope for mankind.

The Use of Money in Enabling Us to Find a Common Denominator of Value

The desirable commodities which constitute wealth may be material goods or immaterial goods (services), and we may find immaterial goods in a concrete form. The services of a carpenter, bricklayer, engine-fitter, or navvy satisfy wants, and are properly termed wealth. We may see any or all of these embodied in material form. Ten thousand bricks in a brickyard are worth less than ten thousand bricks built up as a wall, because not only has other material been incorporated in the wall, but the bricklayer's labour has taken a concrete shape. So it is also with the services rendered by postmen, policemen, doctors, or lawyers, whether or not they take concrete form.

It is important to observe here that the use of money as a standard of value enables us to add together material goods and services of the most varied character, and to express them truthfully as an aggregate. We can state the annual income of a country with near accuracy because the common denominator, the sovereign, values at a single standard the enormous variety of contributions to it. It does not matter how diversely the income may be earned, or how diversely it may be spent. The common standard of value gives truthful expression to values which are not only real, but exchangeable, the one into the other.

For example, a computation of the national income may contain elements as diverse as the wage of a carpenter or the price of a lawyer's fee. On the face of it it may seem absurd to add things so different in character, but a moment's thought will show that these things, diverse as they are, are transmutable.

How Material Things can be Transmuted into Each Other by Money

Having the sum of one pound, we can command with it either carpenter's work or lawyer's work, we can call for quartern loaves or for ballet-dancing, we can fee a physician or command hand-service, we can encourage bookmaking or set men to beer-producing. It is the quality of money to facilitate exchange; and so well does it do its work that any kind of wealth can be exchanged for any other kind of wealth. Services may be bartered for goods or goods for services.

Wealth may be privately or publicly owned; and the increase of public wealth, or what may be termed "public goods," is a remarkable feature in modern economic developments.

Apart from wealth the result of labour, a nation owns collectively wealth which it is difficult to express in values. The United Kingdom, for example, possesses a fine geographical position in the world which facilitates trade. It has a magnificent seaboard and fine natural harbours. It is favoured with an excellent rainfall, temperate climate, and good rivers. All these things are public or collective goods which count enormously in its economy, but which, obviously, cannot be valued in pounds sterling.

Collective Advantages for which a Money Valuation can never be Given

Then there are the collective advantages which arise from its nationhood, the permanency of society, the stability of its internal peace, the security of life and property which it affords, the public spirit and opinion which animate it, the proper pride and traditions which guide it. These are the common property and enjoyment of all its people, and again no money valuation is possible.

Apart from the gifts of Nature and the

common benefits of nationhood, there are the public services which are provided by the State as a whole, or by local authorities within it, which are free to all, and which are paid for by the citizens as taxpayers or as ratepayers. These include defence (Army and Navy), education, policing, roads, bridges, parks, museums, drainage systems, public health services, public lighting, and so forth. A moment's thought will show that it is a sort of framework of individual life which is formed by these public services, or, to vary the metaphor, that individual life and work are, as it were, embroidered upon a general fabric sustained by the community acting as a whole. We are apt to regard established things as commonplace, but the gigantic communal arrangements of modern societies, that make civilised life possible and give a certain security to all, are by no means commonplace. To sustain them raises

A SYMBOLICAL VIEW OF VENICE WHEN SHE WAS AS RICH IN TASTE AS IN COMMERCE

difficult problems of taxation and management, which are of increasing importance as society grows, and as it is felt that a wider communal life is needed. A modern nation becomes more and more a club which furnishes amenities in return for a subscription, nominally of money, but actually of work. How far the process will be carried, and to what extent wealth will come to consist of "public goods," we do not know, but the tendency in this as well as in other countries is to widen the range of public provision.

What wealth have the people of the United Kingdom so far accumulated? The inquiry is one of deep interest, even of fascination. We have been cultivating, manufacturing, and trading, in large and in small, for many centuries. What sort of a stock of wealth has been accumulated?

We can answer this question in one way by capitalising, at a reasonable number of years' purchase, the income which is shown by the Inland Revenue Commissioners to be derived from property. We cannot do this for all forms of property, however. In the case of many publicly owned goods, for example, which do not produce revenues—*e.g.*, roads—we can only form an approximate estimate of value upon common-sense considerations.

The Value of the Property Owned by the British Imperial Government

The British Government owns little property, and in that respect differs from most of the great States of the world. The railways and canals which in other countries are usually State-owned are here private property. The main items of British State property are the British Navy and naval establishments, the British Army material and establishments, the Government dockyards and arsenals, the public offices, museums, picture galleries and their contents, the Post Office businesses and their materials. Two hundred and fifty millions is a conservative estimate of the capital value of the Navy, and the military establishment may be put at £120,000,000. The postal and telegraph businesses are worth fully £70,000,000. Adding the value of the Suez Canal shares and other minor details, we may consider £600,000,000 as a very conservative estimate of the value of British Imperial property.

The British local authorities own much more property than the Imperial Government. We may consider the commons as in their charge for the purposes of this estimate. The British common lands extend to about two million acres. Some of these are situate in districts where land is worth no more than £20 an acre; some, again, are near great centres of population, and have a building value of £500, £1000, or even much more, per acre. If we assume the two million acres of commons to be worth, on the average, no more than £25 an acre, we get a capital sum of £50,000,000.

The Value of the Public Highways and the Undertakings Owned by Local Authorities

Then there are the tens of thousands of miles of public highways. These are not run for commercial profit, but for the general good of trade and the country. They have value as land and value as highways. Some of them run in places where land has little value, others in rich towns where land is at an enormous price. If we take the 22,000 miles of main roads and the 97,000 miles of minor roads as worth £5000 per mile for land and construction, we get, say, £600,000,000 as a not excessive estimate of the value of British roads.

Local authorities own an enormous amount of property in the shape of revenue-producing undertakings, including gas-works, waterworks, electric light and power undertakings, houses, etc. They also own much property which does not produce revenue, such as parks, offices, schools, asylums, workhouses, bridges, sewers, etc. If we refer to the official records, we find that British local authorities had, in 1908-9, an outstanding indebtedness of £510,000,000. The whole of this sum, and much more—for there have been large redemptions of debt—have been spent on the various revenue and non-revenue producing undertakings referred to. At the present time, therefore, the capital value of British municipal works cannot be less than £700,000,000, and it is probably much more.

The Net Value of Public Property When National and Local Debts Have Been Met

Thus British local public property is worth not less than £1,350,000,000, and, adding it to the estimate of £600,000,000 for British Imperial property, we get a total of £1,950,000,000 for British publicly owned capital.

But there is the National Debt and local indebtedness to consider, and for the purposes of our estimate it is convenient to regard them as mortgages upon the publicly owned property. The National Debt amounts to £730,000,000, and local indebtedness, as we have already seen, to £510,000,000. That makes a total public indebtedness of

£1,240,000,000; and if we deduct this from the total estimate of £1,950,000,000 worth of public property, we arrive at £710,000,000 as the value of British capital which is in public possession. Although the debts are not truly mortgages upon the public property, by treating them in this way we get an accurate picture of the nature and extent of British collective ownership, and we are also enabled to treat the debts themselves as the private property of individuals.

The Value of Privately Owned Land, Houses, and Buildings

We have next to consider the large amount of property which is held by British private citizens. This partly consists of property in the United Kingdom, and partly, again, of investments in places oversea.

Beginning with the former category of British wealth, we have first to consider agricultural lands and the buildings thereon. A farm, of course, is not merely "land," it is a manufactured article, and, if it is in good heart, a very highly manufactured article. In the last year for which we have revenue returns (the financial year ended March 31, 1910, referred to briefly as 1909-10), the profits from the ownership of agricultural lands were returned as £52,000,000. If we value this at twenty years' purchase, we get a capital value of £1,040,000,000, which covers, be it remembered, all buildings and improvements upon the land.

The next item is a very important one—viz., the houses and other buildings of the United Kingdom (other than upon agricultural land) and the land upon which they are built. The value of the land and houses cannot be stated separately, but together they brought in, in 1909-10, a gross income of £219,000,000. As we are capitalising gross and not net income, we capitalise this sum at fifteen years' purchase as a not excessive valuation, and this gives us the great sum of £3,285,000,000 as the value of the houses, offices, warehouses, and other buildings of the United Kingdom.

The Value of Farmers' Capital in Stock, Machinery, and Stores

Miscellaneous profits from land are returned as yielding £1,300,000, and if we capitalise this at twenty-five years'purchase we get £32,000,000 to add to the value of British land.

We have next to estimate the value of farmers' capital, including animals, implements, machinery, plant, stores, etc. There are 47,000,000 British acres under cultivation, and £6 per acre is the lowest reasonable estimate of the capital so employed. This gives the sum of £282,000,000.

Coming to consider the National Debt and the debts of local authorities, these, it should be remembered, represent sums lent to the State and to local bodies by private persons. The private persons who are the lenders regard their securities as property, and the method we have adopted enables us to treat the amount of the debts as private property, since we have deducted them as mortgages from the estimate of the value of publicly owned capital. The sums of £730,000,000 (National Debt) and £510,000,000 (local debts) have therefore to be added to our estimate of private property.

A very important item has next to be considered—the amount of capital employed in British trade and industry. The gross amount of profit returned under Schedule D of the Income Tax (Trades and Professions) in 1909-10 was £419,000,000. Some of this was profit from abroad; on the other hand, a certain amount of business profit undoubtedly escapes taxation.

The Probable Total Value of Capital Used in Trade and Industry

It is exceedingly difficult, on these and other grounds, to state with confidence what part of the £419,000,000 can be regarded as derived from the ownership of capital used in the United Kingdom. Moreover, the year 1909-10 was not one of full receipt of income tax, owing to the political difficulties in connection with the passing of the Finance Act of 1909. It is believed by the present writer, who has gone very closely into the matter, that not less than £230,000,000 of profit can be regarded as derived from business capital employed in these islands; and if we capitalise this at ten years' purchase we get a figure of £2,300,000,000, which is probably a very conservative estimate. Indeed, we should not be inclined to quarrel with a much larger estimate.

The returns of joint-stock companies show that in 1910 the total "paid-up" capital of such concerns in the United Kingdom amounted to £2,179,000,000. This figure includes much purely nominal capital and some capital invested abroad. As, however, a considerable amount of business capital is not on a joint-stock basis, the figure goes to confirm our view that £2,300,000,000 is a conservative estimate of British trade capital.

We have to add something for the capital of retail traders and others who do not pay income tax, and £100,000,000 is suggested as a reasonable estimate; it has no statistical basis, however, and the true total may easily be more or less than the figure named. The possible error here is not of much importance, however, in relation to the aggregate we shall arrive at.

The next item is of great importance—the capital value of British railways. The latest railway returns give these figures.

THE PROGRESS OF UNITED KINGDOM RAILWAYS DURING FORTY YEARS

Year	Mileage	Nominal Capitals	Net Profits	Average Profit
		£	£	Per Cent.
1870	15,537	530,000,000	23,400,000	4·4
1880	17,933	728,000,000	31,900,000	4·4
1890	20,073	897,000,000	36,800,000	4·1
1900	21,855	1,176,000,000	40,100,000	3·4
1910	23,387	1,318,000,000	47,400,000	3·6
1911	23,417	1,324,000,000	48,600,000	3·7

The nominal capital of British railways is not real capital. As much as £200,000,000 consists, it is shown in the official returns, of nominal additions created by the simple process of splitting or "watering" stock, and thus turning a certain quantity of stock bearing a high rate of interest into twice the quantity bearing one-half the rate of interest. Over and over again large blocks of stock have been dealt with in this way. That is why the last column of the above table shows a fall in the rate of return on capital. There has been no real fall of such magnitude. In 1911 the average rate of interest earned on all the capital employed, exclusive only of the nominal additions referred to, was, it is shown in the official railway returns (Cd. 6306 of 1912), 4·2 per cent. This is excellent when it is remembered that all companies are included, however unnecessary or unsuccessful.

To arrive at an estimate of railway capital for our present purpose, therefore, we neglect the nominal figure of £1,324,000,000 in view of the nominal additions, and take the 1911 profits, £48,600,000, at twenty-five years' purchase, which gives £1,215,000,000.

Turning to mines and quarries, we have a security which must only be valued at a moderate number of years' purchase. The 1909–10 profits (which include royalties, say, £7,500,000) were £18,500,000. At ten years' purchase this gives a capital value of £185,000,000. The capitalisation of mining property is sometimes taken at a smaller number of years' purchase.

The next item is gasworks. In 1909–10 the profits were £7,400,000. At twenty years' purchase this gives us £148,000,000. The profits of gasworks show a tendency to decline, and indeed it can only be a matter of time before progress makes them quite obsolete.

Ironworks had in 1909-10 a profit of £3,800,000, and if we value this at ten years' purchase we get a capital sum of £38,000,000. The average profits are usually higher than this in an ordinary year. We come next to waterworks, with a profit of £6,100,000, which at twenty years' purchase gives £122,000,000.

As we have seen in the previous chapter, British canals do not count for much in the national economy. It is deplorable to find that in 1909–10 canals, including docks, etc., yielded only £4,000,000 of profit, which at twenty years' purchase we put at £80,000,000. If there had been proper canal development, even under private ownership, this means of transport would figure for very much more in the national valuation.

There remain under Schedule D of the Income Tax a number of miscellaneous items yielding in 1909–10 about £9,000,000 of interest or profit, which, capitalised at twenty years' purchase, gives us £180,000,000.

It remains to form an estimate of the value of the furniture, works of art, etc., in the private houses throughout the country. There is no possible way of arriving at an estimate which can pretend even to be approximate. Sir Robert Giffen once estimated furniture at one-half of the value of the freeholds of the houses containing it, and this example has been followed by others, but surely there is no justification for so high a valuation. Such an estimate may be justified in the case of some rich men's houses, but the great majority of British houses are inhabited by the working classes and the lower middle class, who usually have very little furniture indeed. It seems to the present writer that if we take one-sixth of the valuation we have made of houses—*i.e.*, one-sixth of £3,285,000,000, or, say, £540,000,000—we get a more reasonable estimate, but still one which can only pretend to be intelligent guesswork.

That ends our estimate of the value of the private property of British citizens, so far as it relates to property situate in

the United Kingdom. The aggregate of the estimate is £10,787,000,000.

With regard to property in places oversea held by persons in the United Kingdom, a careful estimate has been made by Sir George Paish, for the year 1910. The figures are extraordinary, and show what an enormous lien the United Kingdom possesses upon the work of foreign countries and British possessions.

THE UNITED KINGDOM'S CAPITAL INVESTMENTS IN FOREIGN COUNTRIES AND BRITISH POSSESSIONS

	£
A. In the British Empire:	
North America	372,500,000
Australia	380,000,000
Africa	380,800,000
India	365,400,000
Other Asian Possessions	30,300,000
Other British Possessions.. ..	25,000,000
Total British Possessions ..	£1,554,000,000
B. In Foreign Countries:	£
United States	688,100,000
Argentina	269,800,000
Other Latin Americas	340,600,000
Asian Countries	105,000,000
Europe	150,000,000
African Countries	84,200,000
Total Foreign Countries ..	£1,637,700,000
ALL THE WORLD..	£3,191,700,000

The investments, it will be seen, are almost equally distributed as between the British Empire and foreign countries, and have played a great part in developing the New World. They produce effects of great magnitude in our commerce, for the interest upon them, when drawn into the United Kingdom, is received in the form of imports of food, materials, etc.

The total thus arrived at, as will be seen in a summary below, is £14,689,000,000, and of this as much as £13,979,000,000 is the property of private individuals. As there are about 9,000,000 families in the country, this gives an average per family of about £1550. The distribution of the aggregate is very unequal, for of £300,000,000 which passes at death in an average year, £200,000,000 is bequeathed by only 4000 persons!

It does not necessarily follow that a capital valuation expressing economic wealth also expresses well-being.

If we consider the item Houses and other buildings and their lands, which we have valued at the great figure of £3,285,000,000, there is nothing in this figure to tell us what it represents in comfortable and healthy homes. Unfortunately, we know that some part of it stands for slums, and that another part, by no means small, stands for rows of mean houses which are far from being ideally healthy home-places.

Neither do the figures constitute a surprising total when we consider that the nation consists of over 45,000,000 people.

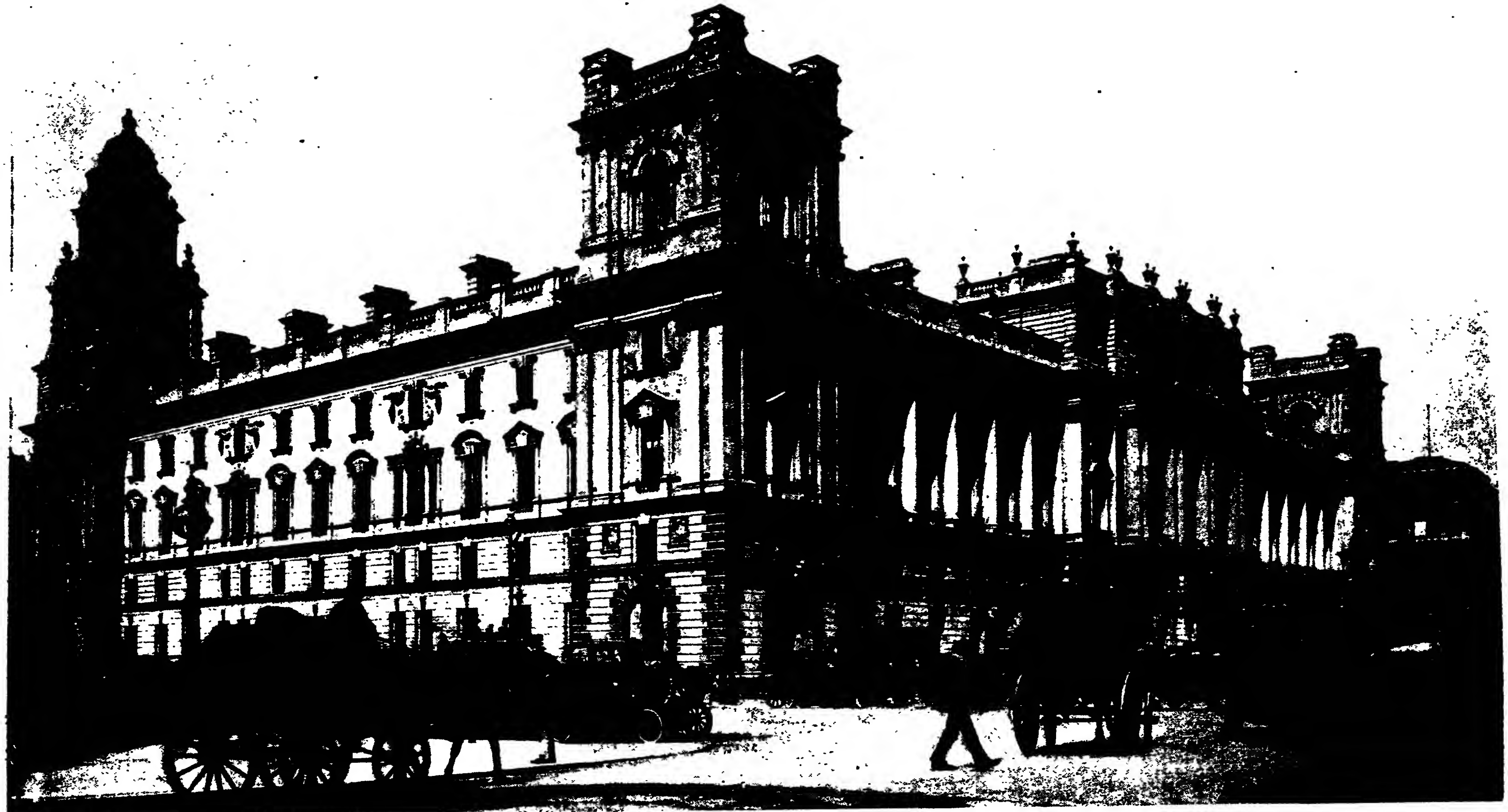
The valuation we have made, moreover, includes the market value of the land of the United Kingdom, which is not the work of man; and if this is subtracted the capital in the United Kingdom is much reduced.

Thus our examination of facts relating to British accumulated wealth, while satisfactory from one point of view, should fill us rather with holy discontent than with complacence. With the beginning of the nineteenth century as a background, the position in 1912 appears one of great progress and achievement, but we have not yet successfully won from the pursuit of wealth the conditions of well-being for the majority of our people. Trade has yet a world to conquer.

ACCUMULATED CAPITAL OF THE UNITED KINGDOM, 1910

	£
(1) PUBLICLY OWNED PROPERTY:	
(a) Imperial property	600,000,000
(b) Local authorities	1,350,000,000
	£1,950,000,000
Less National Debt (£730,000,000) and Local Debts (£510,000,000)	1,240,000,000
	£710,000,000
(2) PROPERTY IN THE UNITED KINGDOM OWNED BY PRIVATE PERSONS	£
(c) Agricultural lands, buildings, etc.	1,040,000,000
(d) Houses, trade premises, and their lands	3,285,000,000
(e) Other landed property ..	32,000,000
(f) Farmers' capital	282,000,000
(g) National Debt	730,000,000
(h) Local debts	510,000,000
(i) Trade capitals	2,400,000,000
(j) Railways	1,215,000,000
(k) Mines and quarries	185,000,000
(l) Gasworks	148,000,000
(m) Ironworks	38,000,000
(n) Waterworks	122,000,000
(o) Canals	80,000,000
(p) Miscellaneous properties ..	180,000,000
(q) Furniture, etc.	540,000,000
	£10,787,000,000
(3) OVERSEA INVESTMENTS	3,192,000,000
GRAND TOTAL	£14,689,000,000

THE CENTRAL GOVERNMENT OFFICES WHENCE LOCAL AUTHORITIES ARE SUPERVISED



THE OFFICES OF THE LOCAL GOVERNMENT BOARD AND THE BOARD OF EDUCATION, IN WHITEHALL

A SOUND USE OF THE LAWS

The Need for Co-operation Between the Central Governing Body and Local Authorities

SOME PROBLEMS OF ADMINISTRATION

We have referred already to the present-day growth towards ideal government in towns, taking as a starting-point things as they exist, and more particularly as they exist in England. Perhaps something may be said also, in a practical spirit, on the general government of the country, with special reference to problems that prevent government from becoming ideal. An enormous amount of public and party machinery is brought into operation that legislators with energy and enthusiasm may be sent to Parliament. The Legislature, so energetically formed, works diligently at law-making, and in the course of a few years passes many new laws and revises many old ones, until the mass of laws conceived for the good government of the country is prodigious in volume; and yet, wherever one settles to live, whether the district be rural, urban, or metropolitan, the practical government of that place is anything but ideal.

Why is that? The laws are in existence that would make life healthy, pleasant, and well-conditioned, but they are not put into operation, owing to leakages that occur between law-making by Parliament, law-launching and supervision by Government departments, and administration by local bodies that practically apply—or do not apply—the laws. There is no insurmountable difficulty in making any district in this country an example of ideal government, but it is not done; and we wish to suggest some reasons why it is not done. We approach ideal government by way of things as they are, a consideration of details, and an inquiry as to how practical government may be improved.

No doubt it would be easier to follow the customary course when the word "ideal" is used, and to examine the principles underlying popular government, as they have been expounded by the great publicists of all time; then to trace the different schemes that have been built on these principles by thinkers, or by more or less practical statesmen; and next to illustrate merits and dangers by reference to historical experiments, developments, failures. Lastly, one might construct a scheme, ideal from its first conception in principle to its consummation in supposed practice; but everyone knows that such schemes have always been as pretty but as insubstantial as a blown bubble. They have never grown out of life, but only out of a play of imagination as remote from realities as sheet lightning is from working electricity. So we prefer to take our stand on the most advanced practical forms of government evolved by man's experience, and to ask how they may be modified in the direction of the ideal. Human nature knows of no such expedient as clearing the ground and beginning afresh. It builds directly on what is here.

The ideal is always with us, of course, working inside of every movement and developing changes, though we can never certainly read its record, or be sure of its exact whereabouts, much less picture it as an organic whole. It is moulding our conception of the greatest entities—the State, property, rights in land, public duty, and so forth—and none of us can tell precisely where we are travelling under the largely unrealised compulsion of influences which are in the air. We are not under-valuing the ideal that, apart from our volition, is coming into being, but we prefer to base our studies on the tangible.

Let us suppose that our framework of government is sufficiently sound, and indeed could not well be bettered—a very large supposition; that we have approximately a representative Government, both general and local; that the system of choice is

such that electoral power is justly distributed; that all have votes who ought to have them; that the people elected represent in each case a majority; that the Legislature is expressing the public will in its proposals, without unreasonable delay; that law-making, therefore, has been carried on under the most favourable circumstances, and that practical government is about to begin through its administrative branches. This, then, is the stage at which we inquire how an ideal Government can be more nearly approached.

When we examine in detail why some parts of a country are well governed and others ill-governed, under the same laws, and with the same machinery of government, we are brought face to face with a condition of things that is interesting in itself, and that explains the curious ideality and want of ideality observable in various parts of the same country. The general law of the land has said that certain important elementary conditions of successful social existence may be enforced. A district may have good water provided, lighting, and sound roads, education of a nature varied to suit its wants, allotments for its labouring classes, and such sanitary arrangements as will ensure the absence of nuisances.

Why is it that Good Laws are Not being Carried Out?

The list of possible advantages may be continued until the government of the region approaches the ideal—on paper. And yet, in fact, there may be scarcely any of these advantages in actual operation.

How does that come about? Largely it is due to the clash between ideas—if not the ideal—as represented by the central law-making Government and its departmental supervisors on the one hand, and the un-ideal or "un-idead" local administrators upon whom, on the other hand, falls the duty of putting the laws into operation. But the position is by no means so simple as that all round, for sometimes it is the central department of the Government that is backward and restraining, and the local administration that has insight and courage, and is prepared to go forward to ideal conditions that would be an enormous gain economically and otherwise. And, further, the case is complicated by the fact that whether one side or other of the two-wheeled machine of government—the central and the local side—be slow or easy in movement, there are inherent difficulties in a country that is constantly changing, here and there, from a scattered population and extreme rural conditions to the elaborations of town life. Inevitably a good deal of the government of a country must be carried on largely, if not entirely, from national headquarters, because it has a distinctively national character. The administration of naval and military business falls so exclusively into this category that it is inconceivable in any other form. So, too, with the dispensing of legal justice in serious cases, and the collection of the country's taxes.

Should the Laws Relating to Education be Administered Nationally?

Many think that education, now so fully nationalised, might be regarded still more completely as applying to the whole country rather than to separate localities. Why should one child be favoured and another handicapped by local energy or remissness in doing national work? The whole range of the country is before the scholar when he leaves school. He is educated for England and not for Little Peddlington; and the country should see to it that opportunities of education are fairly equalised between district and district, as far as the exigencies of residence will allow.

The lighting of the coast has long been regarded as a national duty and an international responsibility. Regulation of fisheries must be on a scale as large as the migration of fish, otherwise the subject will only be played with at isolated points. Similarly, preservation of the coast from erosion is much more than a local duty, and, indeed, cannot be satisfactorily effected locally. Surveys are executed on a national scale, and supersede all local work of the kind. The supreme example of efficiency in doing a national work as it never could be done except by a central authority is of course the Post Office—a marvel of precision, safety, and cheapness.

Departments of Administration that might be Nationally Worked

Some hold the opinion that for business reasons and scientific economy much other work could be centrally controlled and co-ordinated with great advantage, as, for example, all the great lines of communication—roads, railways, and canals; while national drainage and the adjustment of claims to the water supply gathered in the hills and in the underground reservoirs are matters in which justice between district and district could best be arrived at by national schemes of engineering based on a comprehensive view of national wants.

Though central administration is essential in some respects, and is well carried out,

everyone who has seen public life at close quarters knows that, in many departments of administration, local knowledge and co-operation are of even greater importance, and that for want of a satisfactory system not only local business but national business is impeded and often spoilt. It is so with law-making. Scarcely any law affecting the whole community is put on the statute book without provisions being included that are unworkable, and would have been shown to be unworkable if they had been submitted tentatively to experienced local workers.

Why do New Laws so often Prove Unworkable at Once?

The fact is that laws are drafted by officials who are far off from practical life; and the moment such laws come into operation they are known to need amendment, even when their legal interpretation is unexpectedly clear. It is not adaptation to purely local circumstances that is wanting, but adaptation to such broad conditions as country life when compared with urban or with metropolitan life. What is needed is a body of advisory practical opinion—quite apart from party politics—to which consultative appeal could be made before any new law is finally drafted.

Perhaps the plainest instances may be found in educational proposals. The Board of Education has been engaged for years in making admissions that what it once did was wrong—in spirit and in detail. Why was it wrong? The cause is found in its evolution of schemes out of the official consciousness without consultation with practical persons. And the very Board that is busy admitting former mistakes goes on to initiate new mistakes of its own, because it will not make sure beforehand how its proposals will work out.

The Good and Bad Points of Government through Bureaucratic Departments

A consequence of this aloofness is that every new proposal is a source of friction, followed by controversy and withdrawals. Seeing it is so abundantly clear that centralised government must tend to build up a bureaucracy, with the manifest disadvantages of a bureaucracy, the wonder is that the danger is not constantly counteracted, as it might be, by wider and franker consultation and discussion with skilled and experienced voluntary administrators who have no personal ends to serve. There should be instinctive correction of bureaucratic weakness.

What are the dangers of a bureaucracy? Besides a tendency to coldness, hauteur, official self-satisfaction, and assumed superiority—human weaknesses that may be observed from the post-office counter up to the heads of the great supervisory State departments—there is the much more practical danger that each office will try to standardise all its doings so that the work may give the least trouble, and may be managed by the fewest possible rules and decisions. All bureaucratic government has a horror of exceptions, though justice and wisdom depend far more on the management of exceptions than on the application of convenient model rules which strike a mean between all the exceptions.

The advantage of bureaucracy is that it tends to enforce at least a minimum amount of efficiency. It absorbs some general ideas from legislation; and though it may hold them woodenly it holds them strongly within narrow bounds, and is inclined to enforce them rigidly. Thus, out of the many ideas which Parliament throws into the form of permissive law, some are steadily pushed into use by the Government departments under fixed officials.

Does Parliament Move Faster than Public Opinion, or More Slowly?

By the way, there is a feeling abroad in certain circles that Parliament is a slow and backward body, resisting inertly the pressure of public opinion, and only moving at the last moment and recording the public will in laws after that record is long overdue; but the facts are quite contrary to that impression. It is much truer to say that Parliament is an idealistic body that has passed a vast volume of laws which the public inertly refrains from using; and the most real struggle in government is between backward local communities which do not intend to use these laws lest they should incur expense for benefits they cannot at present appreciate, and communities that wish to avail themselves to the fullest extent of every advantage which the ideality of Parliament has placed within their reach. Between these two as a regulating body, trying to strike a sort of average, are the controlling Government departments whose sanction must be gained before any step can be taken locally. To some one or other of these departments, which represent not active constructive government but only control of initiation through the granting of permission, every local authority that would take advantage of the law must come, that its legal proposals may be strained and sifted. And here we reach the crux of the practical application of ameliorative law.

Whatever any locality may wish to do towards putting into operation the existing laws for its own benefit, it must go to the appropriate Government department with a plan that will secure the bureaucratic sanction. If it is a local road that needs improvement for the freer circulation of the local traffic, and every farthing of the cost comes from the locality, the official sanction of a Board in London must be secured, the theory being that the central Board holds the balance of the law even between local persons who may want the improvement and others who may not. Wherever expense of a capital character is to be incurred on fresh enterprises, there the central bureaucracy steps in with its possible veto. Are new sewage works to be laid out then an inquiry must be held. Is a new school to be built--then not only must the need of the school be proved by statistics, but the plans down to the last details must be submitted and sanctioned. This system of checks obtains throughout the whole range of administration in this country; and so not only does the central Government itself administer many laws and some organised departments– like the Post Office– without checks, but it keeps its hand on a throttle-valve that controls every subsidiary administrative agency in the land.

The Absurdity of Minor Officials Giving Sanctions to Great Corporations

The system has manifest advantages and disadvantages, the advantages largely predominating, because the tendency is to bring together, though in a somewhat clumsy way, local and national experience, and correct the one by the other. In some aspects this system of Government sanction reaches a high degree of absurdity. For example, a great city, that includes among its administrators the ablest of its local men, who are managing businesses known throughout the world, employing thousands of workers and capitalised in millions of money, may have determined by an enormous volume of local opinion that some improvement is needed within the bounds of the law, and the detailed plans may have been drawn up with the greatest care by the best experts, and yet the municipality cannot move until some representative of a Government department—who does not embody in his own experience a hundredth part of the authority, scientific and administrative, that is concentrated in the proposal—has heard the evidence in favour of the suggested action, and has given his formal judgment. The absurdity in such a case is manifest.

A community of half a million people cannot do what it likes with its own money until Mr. X has reported in favour of giving it leave. Mr. X knows nothing of the business in hand. Those who know all about it, and whose interests are solely concerned, have to explain it more or less fully to one who does not really know the conditions and cannot readily get to know them; and out of this cursory acquaintance with the facts Mr. X gives leave. Officially, of course, it is not put in that form—his Board gives leave, or sanction, but it is the report of Mr. X that is the pivot on which turns the question whether local enterprise shall or shall not be given free scope.

The Danger of Governing by a Code of Rules to Save Trouble

A Government Board acting on the lines thus indicated is bound in course of time to form a code of precedents for its own guidance; and the inevitable tendency is to cramp procedure within a limited number of rules. New departures are looked on with suspicion, as raising fresh issues, requiring extended regulations, and involving independent judgments instead of an easy settlement according to former rulings; and so there is an instinctive action on the part of a central bureaucracy to repress such initiative as goes beyond well-accredited routine. The Central Board, on receiving the new proposal, has a vision of all the irritation that may be stirred up in unsuitable places, and the trouble it will have in adjusting the new suggestions to diverse circumstances, and so its disfavour is excited, not on the merits of the proposal, but because of the secondary reason that it will cause controversy all round sooner or later.

Pioneer Officials Ahead of the Van of Progress

It would be misleading to suggest that this effect of sterilising new effort is universal in a bureaucracy that controls by giving sanctions. There is in such a bureaucracy a well-marked secondary tendency towards progress. Your official inquirer or inspector comes into contact with ideas--no one more frequently than he—nay, he gets such frequent glimpses of idealism that, given the receptive temperament, he is likely to be infected, and to become, theoretically at least, a disciple of the most advanced pioneers. Thus whatever tendency there may be in officialism as a whole to preserve a somewhat conservative routine, and to judge by the precedent that gives least trouble, the personnel of the official world that comes into contact with original

and formative proposals in administration is likely to contain, and does contain, something more than a sprinkling of men who are "afar with the dawning, and the suns that are not yet high."

Moreover, the whole trend of centralised bureaucratic government is to rally the dead-alive districts until they reach at least a moderate degree of Governmental efficiency. Nothing could be more unjust than to represent the influences of the great Boards in London as if they were retrograde, or even deadening, on the whole. Their record is rather one of rousing the indolent, and declining to be put off with schemes that are inadequate and unscientific. A Government department of reference has abundant opportunities of easing the path of progress. And that it does, thanks largely to the idealists whom it harbours. Though the bureaucracy lives in a world of its own, and often fails to judge the atmosphere of public life as represented by the elector, it is much oftener engaged in crying "Forward" to the laggards than in crying "Back" to the idealists.

The Growing Need for a Government Office in Each Village

Nor is it easy to see how otherwise than through some such departmental organisations as now exist there could be kept up that touch between national organisation and local effort on which so largely depends combined soundness and ideality in government. Indeed, a time is near at hand when, in order to perfect and unify the administrative operation of the laws, some advance must be made towards organising national services locally. In recent years laws have been passed that have established direct connections, such as had no existence before, between the inhabitants of each village and the central Government. Thirty years ago there were only two or three rather slender threads linking each village with His Majesty's Government. Popularly, there was the Post Office, which fulfilled such simple services that the widow who kept one of the general shops of the place could perform its duties passably well. Then there were tax-collectors, who made themselves felt once or twice a year; the Excise officers, who kept an eye on drink production; the distributors of income-tax papers to a few; and the police who watched licences. The local Justice of the Peace was also a representative of the ubiquitous law. When these spasmodic activities were quiescent the presence of the Central Government was not felt. Now it is far different. If the operations of government that are on a national scale are to be carried out properly, every village or group of villages with, say, five hundred inhabitants needs a Government dépôt or branch that should be nationally sustained, but that should work in close harmony and conjunction with the local authorities.

Functions that Might be Fulfilled in a Village Post-Office

The work that is done, or might be done, in the rural post-office, for example, is enormously greater than it was, for it is the natural gathering-point of all public responsibilities of a national character. Not only are there the old age pensions, over which the official in charge should have supervision, but there are the insurances under the new Act; the working of the health section of the Act, with a register of tuberculous cases; and who so competent as the head of this department, who knows every house and everybody, to make up the register of voters under whatever franchise may be adopted?

The post-office, in short, should be a centre of complete local information with a national bearing, and should have someone in charge who could transact all Government business without any overlapping of work between department and department. A local Government bureau of this nature would provide promotion for many competent men who leave the national Services without any prospect beyond an inadequate pension, and therefore should not be expensive. It would form a centre of working for all future extensions of "social" law.

The Utilisation of Local Experience for Advisory Purposes

If it be said that the cost of highly qualified services would be considerable, why could not a double purpose be served by the use of fairly educated, sensible, practical, business-like people, with a committee of local advisers to help in consultation should difficulties arise? In this way national work and local voluntary work could be welded together into a new efficiency, experience be utilised, and unity of work be attained. The ideal of sound administrative government is to be reached along the line of co-operation in national schemes between a centrally managed staff and advisers who will bring forward the practical teachings of local experience. For want of such co-operation practical information does not reach Parliament when laws are being made, and afterwards the laws are not applied with the economy that is possible.

WEDDED

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BY LORD LEIGHTON

FROM GALTON TO ELLEN KEY

The Inevitable Failure of Any Attempt to Make a General Application of Eugenic Control

RESTRICTION VERSUS CONSTRUCTION

If we are going to study the conditions under which a practical eugenics may be possible, and the ideas which must underlie such practice, we may well begin with the contributions to this subject of the founder himself. These have been conveniently gathered together in a little volume, entitled "Essays in Eugenics," which should certainly be in the possession of every serious student of the history of eugenics. Any bookseller can obtain it from the publishers, the Eugenics Education Society, and its price is only one shilling. The principal papers here reprinted were prepared for the Sociological Society a society that deserves acknowledgment for its services to eugenics long before any eugenic societies existed. But here we shall survey all these papers, extending over practically the last septennium of Sir Francis Galton's life, as a whole, seeking therein not for laws of heredity, which are very different from what he believed, but for suggestions as to practical methods of achieving eugenics. Not details yet, but principles, we are considering. Briefly, but accurately, are we to achieve eugenics through law, or through love and liberty?

Certainly, Galton advanced, in some four decades, from the idea of regulation by law to that of regulation by public opinion, as he has told us; but when we have examined his final judgments we must judge for ourselves how feasible they are, and how much they may be expected to effect. And then we shall see whether something even deeper and more potent than public opinion cannot be—has not been—justly invoked in the name of eugenics.

Here, in the first place, are the directions which Sir Francis Galton laid down before the Sociological Society at its never-to-be-forgotten meeting on May 16, 1904. As far as possible we shall use his own words.

"1. Dissemination of a knowledge of the laws of heredity, so far as they are surely known, and promotion of their farther study . . .

"2. Historical inquiry into the rates with which the various classes of society (classified according to civic usefulness) have contributed to the population at various times, in ancient and modern nations. There is strong reason for believing that national rise and decline is closely connected with this influence. . . . It may be expected that types of our race will be found to exist which can be highly civilised without losing fertility; nay, they may become more fertile under artificial conditions, as is the case with many domestic animals.

"3. Systematic collection of facts, showing the circumstances under which large and thriving families have most frequently originated; in other words, the *conditions* of eugenics. The names of the thriving families in England have yet to be learnt, and the conditions under which they have arisen. . . . The definition of a thriving family, such as will pass muster for the moment at least, is one in which the children have gained distinctly superior positions to those who were their classmates in early life. . . . The point to be ascertained is the *status* of the two parents at the time of their marriage, whence its more or less eugenic character might have been predicted, if the larger knowledge that we now hope to obtain had then existed. . . . Finally, the reasons would be required why the children deserved to be entitled a 'thriving' family, to distinguish worthy from unworthy success. This manuscript collection might hereafter develop into a 'golden book' of thriving families. The Chinese, whose customs have often much sound sense, make their honours

retrospective. We might learn from them to show that respect to the parents of noteworthy children which the contributors of such valuable assets to the national wealth richly deserve. . . .

"4. Influences affecting marriage. The remarks of Lord Bacon in his essay on death may appropriately be quoted here. He says, with the view of minimising its terrors: 'There is no passion in the mind of men so weak but it mates and masters the fear of death. Revenge triumphs over death; love slights it; honour aspireth to it; grief flyeth to it; fear pre-occupateth it.' Exactly the same kind of considerations apply to marriage. The passion of love seems so overpowering that it may be thought folly to try to direct its course. But plain facts do not confirm this view. Social influences of all kinds have immense power in the end, and they are very various. If unsuitable marriages from the eugenic point of view were banned socially, or even regarded with the unreasonable disfavour which some attach to cousin-marriages, very few would be made. The multitude of marriage restrictions that have proved prohibitive among uncivilised people would require a volume to describe.

"5. Persistence in setting forth the national importance of eugenics."

The Limited Use of Restriction Compared with Getting the Right People to Marry Each Other

To little of this, as far as it goes, can we offer any objection, though there is a clause about marriage restrictions among uncivilised people which may well alarm students of another section of POPULAR SCIENCE, who know, for instance, the kind of thing to which the primitive Australians had to submit. But this question of the feasibility of restrictions in marriage led Sir Francis Galton on to further inquiries, which issued in his paper, "Restrictions in Marriage," read before the Sociological Society in the following year.

In summarising that paper, let us observe how very short is the distance which restrictions in marriage take us towards positive eugenics. Obviously, they can do little more than serve what we call negative eugenics, though Sir Francis Galton scarcely seemed to see this at the time. At bottom, and above all, eugenics means getting the right people to marry each other; and though restrictions in marriage may serve that end indirectly, to some slight degree, they do not take us very far. Further, they presuppose anything but a free community; and the question of their applicability to a free modern community, and without the superstitious-religious sanctions which alone made them possible in the past, remains for settlement. However, here are the conclusions which the author reached.

His object was "to meet an objection that has been repeatedly urged against the possible adoption of any system of eugenics—namely, that human nature would never brook interference with the freedom of marriage. . . . To this end, a brief history will be given of a few widely spread customs. It will be seen that, with scant exceptions, they are based on social expediency, and not on natural instincts."

Social Customs by which Marriage Has Been Controlled in Various Lands

The wary reader will be anxious in presence of this antithesis between what serves society and what is natural, and may remind himself of what we have already declared—that, in direct conflict between eugenics and human nature, eugenics will surely be broken.

Sir Francis goes on to show how men have submitted to such restrictions as monogamy, at the end of his account of which he says: "I conclude that equally strict limitations to freedom of marriage might, under the pressure of worthy motives, be hereafter enacted for eugenic and other purposes." Similarly, there was endogamy, the custom of marrying exclusively within one's own tribe or caste, on which the comment is that "similar restrictions have been enforced in multitudes of communities, even under the penalty of death. . . . Family property and honour were once held by the Jews to dominate over individual preferences. The Mosaic law actually *compelled* a man to marry the widow of his brother if he left no male issue. . . .

If Family Descent be a Controlling Motive, why not Racial Vigour?

"Evidence from the various customs relating to endogamy shows how choice in marriage may be dictated by religious custom—that is, by a custom founded on a religious view of family property and family descent. Eugenics deals with what is more valuable than money or lands—namely, the heritage of a high character, capable brains, fine physique and vigour; in short, with all that is most desirable for a family to possess as a birthright. It aims at the evolution and preservation of high races of men, and it as well deserves to be strictly enforced as a religious duty as the levirate law ever was." (This was the Mosaic law

referred to, and illustrated in the story of Ruth and Boaz.)

Exogamy, the opposite of endogamy, and Australian marriages follow next in the author's list. Then comes the power of taboo, on which his remarks are no less significant, if we wish to understand the point of view of those Eugenists who would follow him. He says: "A vast complex of motives can be brought to bear upon the naturally susceptible minds of children, and of uneducated adults who are mentally little more than big children. . . .

Galton's Contention that Non-Eugenic Unions Might be Prevented by Social Disfavour

"My contention is that the experience of all ages and all nations shows that the immaterial motives are frequently far stronger than the material ones, the relative power of the two being well illustrated by the tyranny of taboo in many instances. . . . In most parts of the world, acts that are apparently insignificant have been invested with ideal importance, and the doing of this or that has been followed by outlawry or death, and the mere terror of having unwittingly broken a taboo may suffice to kill the man who broke it. If non-eugenic unions were prohibited by such taboos, none would take place."

With all due deference to the work and memory of our pioneer, we may admit that here he approaches perilously near the realm of the ridiculous. Surely it is not suggested that modern communities are to be treated as the medicine-man treats his tribe, and that we are to control the lower classes (presumably), like "big children," by means of taboos so believed in that a man who has broken one may die of terror? And if that is not the proposal, what is the relevance of the citation?

Prohibited Degrees of Marriage and Clerical Celibacy Proofs of Marriage Control

Finally, the author quotes the prohibited degrees of marriage, and the widespread practice of celibacy, to show what restrictions in marriage man has submitted to. On the whole, he concludes, "It is easy to let the imagination run wild on the supposition of a whole-hearted acceptance of eugenics as a national religion; that is, of the thorough conviction by a nation that no worthier object exists for man than the improvement of his own race, and when efforts as great as those by which nunneries and monasteries were endowed and maintained should be directed to fulfil an opposite purpose. I will not enter further into this. Suffice it to say that the history of conventual life affords abundant evidence on a very large scale of the power of religious authority in directing and withstanding the tendencies of human nature towards freedom in marriage.

"Seven different subjects have now been touched upon. They are monogamy, endogamy, exogamy, Australian marriages, taboo, prohibited degrees, and celibacy. It has been shown under each of these heads how powerful are the various combinations of immaterial motives upon marriage selection, how they may all become hallowed by religion, accepted as custom, and enforced by law. Persons who are born under their various rules live under them without any objection. They are unconscious of their restrictions, as we are unaware of the tension of the atmosphere. The subservience of civilised races to their several religious superstitions, customs, authority, and the rest is frequently as abject as that of barbarians. The same classes of motives that direct other races direct ours, so a knowledge of their customs helps us to realise the wide range of what we may ourselves hereafter adopt, for reasons that will be as satisfactory to us in those future times as theirs are, or were, to them, at the time when they prevailed."

Ought not Love to be Looked on as a Friend by the Eugenist?

On all of this strange writing the best comment, and the most common, will surely be that we want nothing "abject" as a condition of progress. It has too improbable a sound altogether. But this paper of Galton's has been, and is, widely and constantly quoted by Eugenists as the "official" answer to the evident objection which occurs to everyone when he tries to see how eugenics would work. The present writer must acknowledge having quoted this as the final answer in years past. But on further consideration a different opinion must be reached. The reader will judge for himself. The writer now sees clearly three things which he did not see when he was first engaged in trying to advance his master's ideas. First, writing of this kind does not make friends for eugenics. On the contrary, people are afraid of a return to the tyrannies of the past in a new form, and small blame to them. Second, evidence as to the feasibility of restrictions in marriage is no contribution to positive eugenics. That project requires that the right people shall marry, and become parents—two distinct clauses which require to be separately asserted. As a contribution to the achievement

of that end, the study of taboo or Australian marriages is nugatory. Third, wider reading, and constant exposure to popular criticism—an invaluable discipline—have suggested that, except within certain narrow limits, we are on the wrong lines altogether when we propose to achieve eugenics by legal control.

We are looking upon love as an enemy, but a deeper knowledge of the nature of man, and of the problems of sex, may teach us to regard it as a friend. For such knowledge we shall do well to avoid the Continental purveyors of pseudo-scientific treatises on matters of sex, most of which are produced and sold like more honestly evil prints, and are fortunately almost unobtainable in this country. The writers who look upon sex as a species of universal disease, or who are only interested in its morbid manifestations, have nothing to teach us. But we may do well to heed such authors as Professors Geddes and Thomson, who have lately followed up their famous volume, "The Evolution of Sex," with a sixpenny "New Tract for the Times," entitled "The Problems of Sex"; and above all, the writings of Ellen Key, now at last beginning to be accessible in English.

Education of Mrs. Grundy good, but Education for Parenthood better

But first, for the sake of order, let us complete our review of our founder's directions. In the main, these were concerned with the gathering of knowledge, and in that respect they have been wholly superseded by the splendid work of the American school. But a few points as to the application of knowledge may here be quoted. As to the "passion of love," it is only doing Galton justice to quote the following reply to criticism: "The argument has been repeated that love is too strong a passion to be restrained by such means as would be tolerated at the present time. I regret that I did not express the distinction that ought to have been made between its two stages, that of slight inclination and that of falling thoroughly into love, for it is the first of these, rather than the second, that I hope the popular feeling of the future will successfully resist. Every matchmaking mother appreciates the difference. If a girl is taught to look upon a class of men as tabooed, whether owing to rank, creed, convictions, or other causes, she does not regard them as possible husbands, and turns her thoughts elsewhere. The proverbial 'Mrs. Grundy' has enormous influence in checking the marriages she considers indiscreet."

This certainly gives a more reasonable air to the foregoing quotations, and should be read in connection with them. We must try to make a Eugenist of Mrs. Grundy, so that her influence shall be directed to high, instead of to contemptible, ends. And since it is impossible not to play some part in the opportunities of our young people, we can try to direct those opportunities to eugenic ends. It would be absurd, therefore, to say that there is nothing in Galton's argument. On the contrary, it requires careful discussion and will yield real results. But at best it is a small affair, above all when we compare it with the great project of "education for parenthood," which will endeavour to prepare our young people to choose rightly for themselves.

Galton's Plea for Local Histories of Human Stocks

There remains to consider only the last of Sir Francis's papers, dated as late as 1908. It was entitled "Local Associations for Promoting Eugenics," and relates to "that large province of eugenics which is concerned with favouring the families of those who are exceptionally fit for citizenship." The idea was the very reasonable one that local societies should be formed all over the country for the promotion of eugenics. They should inaugurate lectures on the subject, and should especially try to study the facts of the families in their neighbourhood "under the three heads of physique, ability, and character." The societies should hold gatherings, to which they invite most of the notable people of the neighbourhood, and so gradually get to form a local history of the human stock in that part of the country.

Some Possible Happenings if Eugenics ever Became a Quasi-Religion

Some day, even Sir Francis thought, "those who may feel themselves, or be considered by others to be, the possessors of notable eugenic qualities—let us for brevity call then Eugenes—will form their own clubs and look after their own interests. . . . It ought not to be difficult to arouse in the inhabitants a just pride in their own civic worthiness, analogous to the pride which a soldier feels in the good reputation of his regiment, or a lad in that of his school. By this means a strong local eugenic opinion might easily be formed. It would be silently assisted by local object-lessons, in which the benefits derived through following eugenic rules, and the bad effects of disregarding them, were plainly to be discerned. . . .

MANY WATERS CANNOT QUENCH LOVE

THE EVER-RECURRING "YOUNG LOCHINVAR" STORY, AFTER THE PAINTING BY MR. J. WALTER WEST

"In circumscribed communities especially, social approval and disapproval exert a potent force. Its presence is only too easily read by those who are the object of either, in the countenances, bearing, and manner of persons whom they daily meet and converse with. Is it, then, I ask, too much to expect that when a public opinion in favour of eugenics has once taken sure hold of such communities, and has been accepted by them as a quasi-religion, the result will be manifested in sundry and very effective modes of action which are as yet untried, and many of them even unforeseen?

Galton's Idea of Funds to Start Young Couples Possessed of Worthy Qualities

"Speaking for myself only, I look forward to local eugenic action in numerous directions, of which I will now specify one. It is the accumulation of considerable funds to start young couples of 'worthy qualities' in their married life, and to assist them and their families at critical times. The gifts to those who are the reverse of 'worthy' are enormous in amount; it is stated that the charitable donations or bequests in the year 1907 amounted to £4,868,050. I am not prepared to say how much of this was judiciously spent, and in what ways, but merely quote the figures to justify the inference that many of the thousands of persons who are willing to give freely at the prompting of a sentiment based upon compassion might be persuaded to give largely also in response to the more virile desire of promoting the natural gifts and the national efficiency of future generations."

That is the last contribution of Galton to the science and the practice which he founded, and with it we leave him. But we may already guess that it is worth many hundreds of such pages as those on taboos and endogamy.

Marriage and Parenthood Two Entirely Separate Propositions

Indeed, this practical eugenic principle of help for worthy parents may turn out to be a leading line of the future; and it is a great advantage that our founder laid it down, as many now speak in the name of eugenics who are entirely opposed to anything of the kind, but want the return of what they are pleased to misunderstand by the name of natural selection. Fortunately, one can always quote their own founder against these worst enemies that eugenics has to fight.

Let us now face a question, largely implicit in all the foregoing, about which the time has come for honesty and candour. It is perfectly simple, and can be readily discussed without offence to anyone, and the shirking of it stultifies much that is written on this subject. Eugenics is, of course, concerned with parenthood, not with marriage as such. It is open to Eugenists to declare, as all responsible Eugenists do, that they desire parenthood through marriage, though marriage is a large word, and the conditions of eugenic marriage require long and careful discussion. But the time has gone by for ever when we can write as if marriage and parenthood were synonymous. We may and must lay down the principle that parenthood is to involve marriage, and must discuss it at full length, but we certainly cannot lay down the converse principle that marriage is to involve parenthood at all, or, if any, how much. Beca se we are afraid of our own clumsiness in discussing this cardinal point, we avoid it, and argue for the marriage of certain people and against the marriage of others, in the name of eugenics, when in point of fact the business of eugenics is exclusively with parenthood on the part of these people.

The Difference between saying People must not Marry and saying they must not have a Family

Those whose parenthood we desire may marry and have no children, thereby rendering foolish our language. But those whose parenthood we do not desire may marry, and have no children, in which case we find ourselves and our words more foolish than ever.

The fact is that, in our desire to be respectable and *convenable*, we have committed the anything but respectable fault of speaking of mankind as if men and women were as irresponsible and improvident as animals. When animals mate, we reasonably expect them to have offspring. Perhaps time was when we might reasonably have made the same assumption as regards human beings. That time has gone, never to return. Marriage and parenthood are, in fact, in practice, in the real world of today, two distinct things. Eugenics habitually stultifies itself by assuming their constant association. The harm thus done is much greater than those may suppose who had not thought about it. Let us think about it now, and hereafter, in our proposals for practical eugenics, start from assumptions which are more likely to be useful because they are true.

Large and increasing numbers of people, in many parts of the modern world, live

in unions which are not recognised, and may not be recognisable, as marriages. They may or may not have children. Different people will take different views of this modern tendency. Let us argue from the view of the present writer, probably shared by the reader, that, whatever may be true of certain cases, perhaps quite numerous, on the whole this tendency is dangerous and to be deplored. Obviously, it leads towards the decadence of marriage; and though the eugenic arguments for marriage have not yet been set forth in this section of POPULAR SCIENCE, readers of another section will scarcely be likely to view with favour any tendency towards the disappearance of that social institution. Observe, then, one direct consequence of identifying marriage with parenthood. The Eugenist, in the future, much nearer than most of us suppose, would say to many individuals: "You must not marry; in the name of eugenics, you are forbidden." He means nothing of the sort, for marriage as such is none of his business. He means that the people whom he addresses should not become parents.

The Unfortunate Effect on Marriage of Eugenic Restriction of Normal Persons

His embargo may seem to require to be addressed to a surprisingly large number of people. This is the disconcerting discovery made by the American school, since the death of Galton. A large proportion of the community consists of normal persons who will, or would, transmit defects in a proportion of, say, one half of their germ-cells. They cannot be locked up, yet they should not become parents. Are we to say to such people, "You must not marry"? The immediate consequence of this inexcusable and impossible identification of marriage with parenthood would assuredly be to foster largely and rapidly the tendency towards the formation of temporary or permanent unions, which might or might not lead to parenthood, but would certainly have a very unfortunate influence upon marriage. Eugenists who are prepared to talk in this fashion must consider whether they desire, in effect, to abolish marriage, or, at the least, to make inevitable the setting up of substitutes for it by many people, worthy in themselves and in their intentions, to whom no other course has been left open.

Again, it has to be remembered that marriage is a matter of high personal importance, quite apart from parenthood. The eugenic agreement to talk as if the two were one, and to ignore the claims of the individual to "life, liberty, and the pursuit of happiness," does much less than justice to many thousands of thoughtful people, already existing, in this early stage of the eugenic idea, who are married, and have every title to be, but who refrain from parenthood on eugenic grounds.

Surely it is an anachronism for Eugenists to talk to the modern world of the advantages and the possibility of enforced celibacy when it already contains so many brave and faithful and honourable people who have left that stage of human development ages behind. It is idle to deny that they exist.

Restrictions that are now Common in the Interests of the Future

The present writer has been the respectful recipient of letters from scores of them, all over the world, during the past decade. So dense is popular and even medical ignorance in these matters of genetics that in many instances these people have not really been under the eugenic necessity which they supposed. Their personal defect has only been what biologists call *somatic*, confined to the *soma*, or body, of the individual, and not genetic at all. It has been a great privilege, in some such cases, to declare that there was no eugenic reason why such people should not have children, as they desired. In more cases, the self-imposed self-restriction has been necessary in the interests of the future, and has been bravely maintained. There are undoubtedly hosts of such people already. They are often among the heroes and heroines of our race; and it is an idle stupidity which does not trouble to discriminate between them and the many who refrain from parenthood on purely selfish grounds.

The Honour Due to the Natural Eugenists who have Guarded the Future against Disease

Often, when the spectacle of public and political folly and cowardice and lack of forethought seems almost too much to endure, one may remember that all over our globe there are unknown people faithfully doing their duty to man and his destiny without visible reward or praise, perhaps without ever having heard of eugenics, but just because Nature made them Eugenists. Among the great company of the most worthy and unpraised, these who arrest in their own persons the transmissible defects and diseases which afflict mankind, often at the cost of great personal sacrifice, and of more kinds than one, surely

hold a foremost place. If public honour has never been paid them yet, it is paid them now.

But how outrageous, in their presence, is the assumption that no one who would probably or certainly convey some deplorable defect to his or her children should marry—to say nothing of the wild impossibility of such a decree in the face of what we now know regarding the distribution of latent or recessive defects in a population! Eugenists must make up their minds to be a little more discerning and honest, and to see that they must henceforth discriminate between marriage and parenthood, as these people do, and that their duty is so to instruct and moralise public opinion that the number of persons who achieve this splendid solution of a tremendous problem may more nearly approach the numbers of those whose problem it is.

Yet, further, this clumsy and cowardly identification of marriage with parenthood has to reckon with the enormous and steadily increasing number of those for whom parenthood is to be desired, at least on many adequate grounds, if not on all, and who marry, but refrain from having children, for reasons which, we have to admit, are their own affair. In these cases, the labours of the Eugenist may have achieved the marriage which he desires, and then he finds that he is stultified again, though in an opposite direction, as he was by the marriage and non-parenthood of persons having transmissible defects. Is it not clear that no kind of confusion or of compulsion is going to be of any avail here? The problem is a moral one largely, and cannot be solved by confusing the issues.

It has to be accepted, once and for all, whether it be welcomed or deplored, that mankind has become possessed of volition, knowledge, prevision enough to decide, in any given case, whether or not we shall become parents. Marriage has therefore to be reconsidered in the light of the fact that exclusion from it may only tend to ruin it as a social institution, and that *the marriage of the undesirable may do no harm to eugenics, and the marriage of the desirable may do it no good.* The proportion of mankind who may be considered from this point of view steadily and irresistibly increases, as the rapid fall of the birth-rate, even among the working class, in Germany and England as well as France, suffices to show. In the light of these simple and indisputable facts, the idea of eugenics by law becomes more and more ridiculous. Even the control of marriage, which is what most Eugenists demand, the establishment of marriage permits, the handing over of marriage to the Eugenists, instead of to the Churches, is seen to be beside the point once we realise that, in the world of today and the future, marriage and parenthood must be separately considered. What is the use of your certificates if those to whom you grant them do not produce children, and those to whom you refuse them do?

COMMEMORATIVE MEDAL OF THE FIRST INTERNATIONAL EUGENICS CONGRESS

Again we conclude, as on so many other grounds, that in the conflict of principles, law versus love and liberty, law is nowhere. The time for eugenics by law—except, of course, in such cases as the negative eugenics of the feeble-minded—has gone for ever. We must rid our minds of the delusion that that is what we are coming to. It is what we are leaving.

But we are coming to something better; and for that end it behoves us to study anew the conditions of our problem—the facts of human nature, normal, healthy, beautiful human nature, above all in the spheres of sex and emotion.

And here, fortunately, Eugenists who really wish to go on with the moving world are not without wise guides who have seen the coming path from the heights of mind.

SATURN THE MAGNIFICENT

The Story of the Gradual Discovery of Saturn's Retinue — Three Rings and Ten Satellites

A WORLD NOT YET AS DENSE AS WATER

For beauty and interest alike there is nothing in the starry heavens to compare with Saturn. This magnificent planet, unique in the solar system for his encircling rings and ten satellites, forms a spectacle which no one can ever forget who has seen it through a powerful telescope. The whole Saturnian system can be seen nearly at one view, and its perfect proportions are very wonderful.

Until the days of Herschel, Saturn was regarded as the outermost of the attendants upon the sun. For the ancients, he was the least of the seven wandering heavenly bodies, as distinguished from the fixed stars – the seven being the sun, moon, Mercury, Venus, Mars, Jupiter, and Saturn. The glorious rings which surround him were invisible before the discovery of the telescope. Otherwise, this astonishing diadem would surely have saved him from the sinister reputation he bore in the days when he was regarded, by the professors of "a sad astrology," as answerable for misfortunes and calamities of every kind.

Doubtless Saturn was chosen from among the planets to bear the blame of bad luck because of his slow movement among the stars, and also because his light is less brilliant than that of any other of the seven. Seen with unaided vision, he is a star of the first magnitude, but is excelled in brightness by Mercury, Venus, Mars, and Jupiter. This dulness of aspect and lethargy of motion imparted a gloomy, phlegmatic, saturnine character to those who were so unfortunate as to come into the world when Saturn was in the ascendant. It is somewhat remarkable that in those days before telescopes this planet was thought to be the last of the solar system, because Uranus, a planet far outside the orbit of Saturn, is clearly, though faintly, visible by unaided sight. But although the skies had been narrowly watched for many centuries, Uranus escaped observation until his discovery in the eighteenth century by means of Herschel's telescope.

Saturn is so remote from the centre of our system that, viewed from his orbit, the sun would appear as a star of enormous brilliancy, rather than as a disc. He is nearly twice as far from the sun as Jupiter is, and he receives only one-ninetieth of the heat and light we receive on earth. So remote is Saturn that from his surface none of the planets within his orbit, except Jupiter, would be seen at all, the others being merged in the dazzling brightness of the sun; and Jupiter would appear as a companion to the sun, sometimes an evening and sometimes a morning star, as Venus appears to us.

The mean distance of Saturn from the sun is 886,000,000 miles, or about nine and a half times the distance of the earth from the sun. He circles round his orbit once in twenty-nine and a half years, and our earth overtakes him, and comes into line between Saturn and the sun, once in every 378 days, or thirteen days over the year. The orbit of Saturn, which is inclined to the ecliptic by two and a half degrees, is slightly more eccentric than that of Jupiter, so that the distance of Saturn from the sun varies to the extent of about ninety-nine million miles.

The distance of Saturn from the earth varies, according to the position of the two planets in their orbits, from 744,000,000 miles to 1,028,000,000 miles—a variation of distance which is not sufficient to cause any very remarkable difference in the brilliancy of Saturn. At brightest, this planet is not twice as bright as when he is at his greatest distance from the earth.

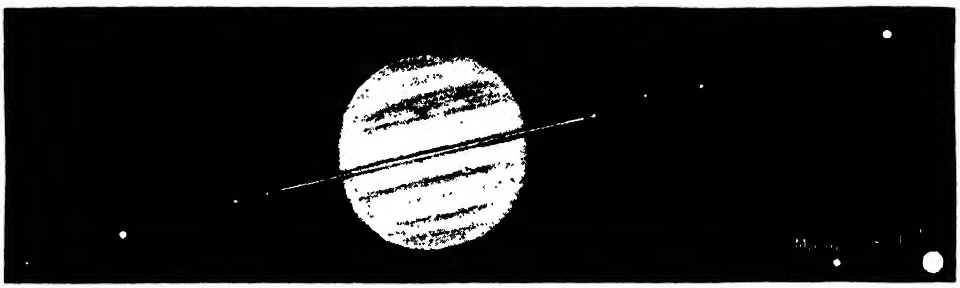
The globe of Saturn is greatly flattened, so that, when the planet is in such a position that the plane of his equator passes through the earth, his profile appears notably elliptical — a feature to which much of his

gracefulness is due. The diameter through the Poles is less by nearly one-tenth than the diameter through the equator, the former being about 68,000 miles and the latter about 75,000 miles. These dimensions show the vast size of the planet, whose volume is about seven hundred and fifty times that of the earth, and about three-fifths of the volume of Jupiter. The superficial area of Saturn is over eighty times that of our globe. But Saturn is so distant from the earth that his vast bulk has an apparent diameter of only from fifteen to twenty seconds.

The density of Saturn is very low, much lower, indeed, than that of any other planet, and even considerably lower than the density of water. With a density of only 72 per cent. that of water, it is evident that Saturn is yet far from having reached the solid condition. Like Jupiter, only in an even greater degree, Saturn is still in a more or less sun-like stage of his evolution, and must cool for long ages to come before he attains the condition of a habitable world. To this molten and even vaporous consistency, together with his extremely rapid rotation, is due the remarkably flattened shape of Saturn. His daily rotation is completed in ten hours and fourteen minutes. This swift revolution on his own axis, first observed by Herschel by means of the cloudy markings on the planet, was exactly measured in 1876 by Professor Hall, of Washington, whose attention was attracted by a brilliant white spot on Saturn's equator. This spot, which appeared to mark a vast eruption of glowing material from the interior, lasted for several weeks, and during that period many astronomers made a close examination of the planet's daily movement.

The axis is inclined to the plane of the orbit by about twenty-eight degrees, giving the planet very much the same slant as the earth has in her orbit. We can hardly speak of seasons in the case of Saturn, who is still in the self-sustained stage, and is consequently enveloped in dense clouds formed by the condensation of vapours due to the planet's own heat, so that the heat and light of the sun have no effect upon his surface. When, however, in the normal course of events, Saturn becomes a world like our own, dependent for light and heat upon the sun, each of his seasons will be more than seven of our years in length.

The visible surface of Saturn has a reflecting power exceeding even that of Jupiter, and this brilliancy is doubtless due to the fact that the reflecting surface consists of cloud. But Saturn appears to be somewhat brighter even than white clouds, from which some have supposed that the light he sends to us is not wholly due to the reflection of sunlight, but is partially derived from the planet's own glow. This is a matter, however, upon which there is much difference of opinion. It is practically certain, at least, that the glowing interior is visible to us, for Saturn has belts like those of Jupiter, only not so clearly marked, and the darker zones have the colour of a red-hot mass. There is a very brilliant broad white belt round the equator, and the Pole has a cap of dull green. Like Jupiter, Saturn is not so brilliant at the edge as towards the centre of his disc. The spectroscope reveals a deep atmosphere which gives certain dark lines that have not been observed elsewhere except in the atmosphere of Jupiter.



SATURN WITH ITS RINGS SEEN EDGEWAYS, AS THEY APPEARED IN 1907
The ten satellites are also shown in this drawing, and Saturn's size may be gauged from the drawings of the earth and the moon.

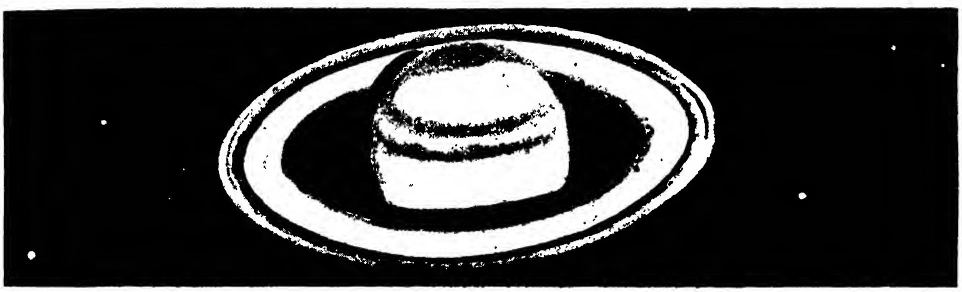
Besides his ten satellites, Saturn is surrounded by a vast swarm of small particles, compared by Clerk Maxwell to brickbats, which circulate about the planet in the form of three concentric flat rings. These rings are unique; nothing like them is known elsewhere in the universe, unless they bear some very remote analogy to the swarm of asteroids which circulate about the sun in the space between the orbits of Mars and

Jupiter. It was long before the shape of these rings was made out, and longer still before their nature was understood.

They were among the first fruits of the telescope. Galileo, in 1610, examining Saturn with his new instrument, came to the conclusion that the planet had a triple form. "When I observe Saturn," he wrote to a friend, "the central star appears the largest; two others, one situated to the east, the other to the west, and on a line which does not coincide with the direction of the zodiac, seem to touch it. They are like two servants who help old Saturn on his way, and always remain at his side. With a smaller telescope the star appears lengthened, and of the shape of an olive." But, continuing to watch this strange portent, month after month, Galileo was amazed to see the two attendants upon Saturn becoming smaller and smaller, until they finally disappeared altogether. He doubted the evidence of his telescope, and doubted even the strength of his own mind. "What can I say," he wrote, "of so astonishing a metamorphosis? Are the two small stars consumed like sun-spots? Have they vanished and flown away? Has Saturn devoured his own children? Or have the glasses cheated me, and many others to whom I have shown these appearances, with illusions?" Thoroughly discouraged, Galileo abandoned his observations of Saturn, and died before these strange appearances had been explained.

Others, however, watched the planet whenever it was in view, and gradually established the fact that Saturn's unique appendages underwent regular periodic changes. They appeared first as bright, straight lines stretching outwards one on each side of the elliptical disc; then, for the next seven years, these lines expanded into two luminous crescents attached to the planet like handles to a dish; and then for seven years more, the crescents became flattened down, until, as before, they were mere lines projecting from Saturn, and finally disappeared altogether. For as the planet pursues his vast orbit, slanting always in the same direction, he twice exhibits his rings, at opposite points in the orbit, edgewise to the earth; and between those two points the surfaces of the rings are exhibited, though always foreshortened, the northern surface being seen for fourteen years and more, and then, for a similar period, the southern surface.

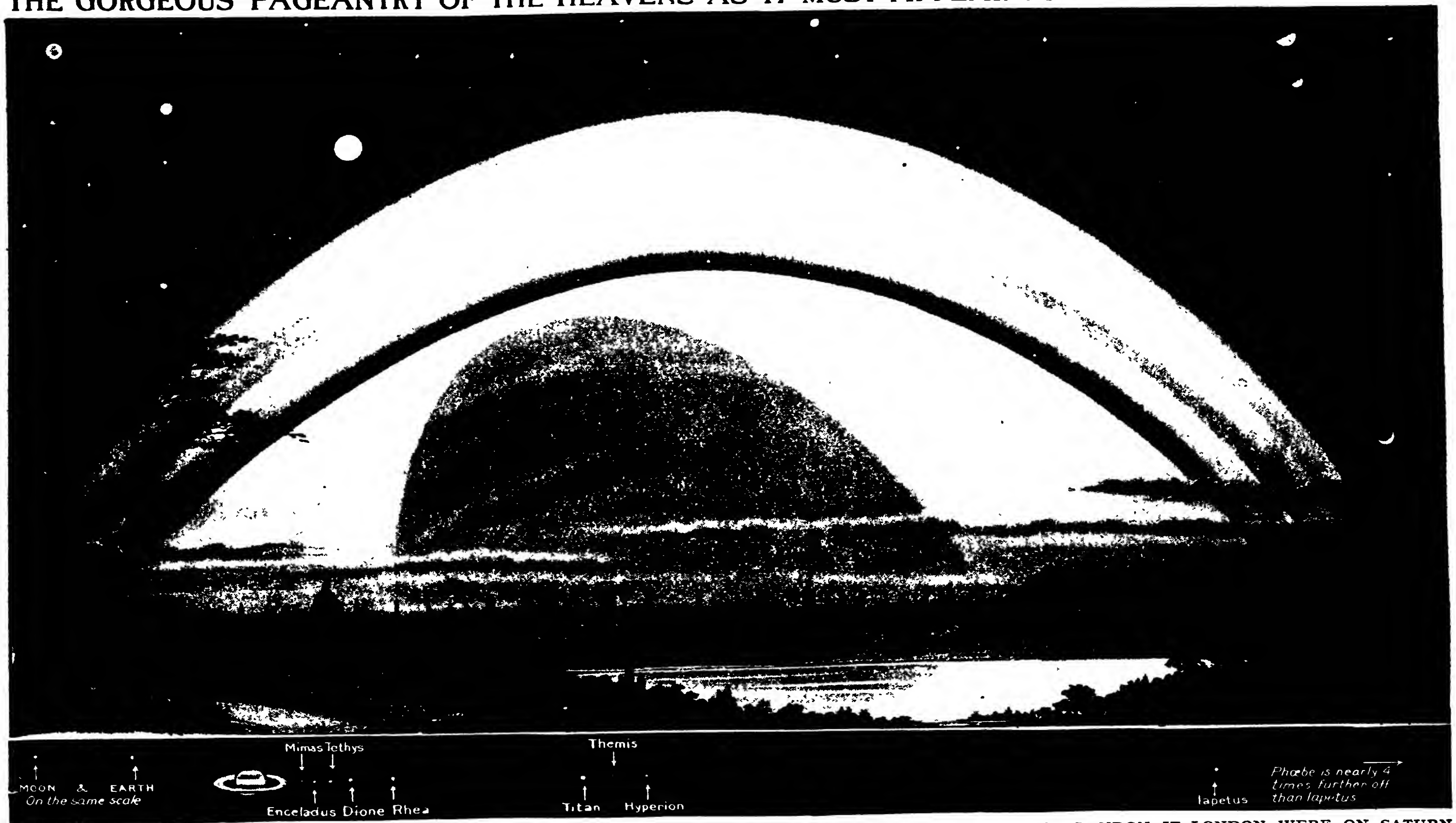
Christian Huygens, a great Dutch scientist and maker of clocks and telescopes, who was the first to bring forward in definite form the wave theory of light, and the first to apply the pendulum to the regulation of clocks, was the first to solve the problem of Saturn's rings. That is to say, he discovered that they were rings, though their constitution was unknown for long afterwards. His discovery was due not only to the greatly improved telescope which his new methods of grinding and polishing lenses had enabled him to make, but also to reasoning power of a very unusual order. Having observed the shadow thrown by Saturn's rings upon his globe, and concluding that Saturn, like other planets, was probably in swift rotation upon his own axis, Huygens perceived that a very thin, broad, flat ring, entirely separate from the planet which it encircled, was the only structure that could give rise to all the various puzzling appearances observed.



SATURN WITH ITS RINGS OPENED OUT TO THEIR MAXIMUM, AS THEY WILL APPEAR IN 1915
The transparency of the inmost "crape" ring, and the shadow cast by the planet on its rings, should be noticed.

Yet this hypothesis was so unprecedented, so amazing, that he hesitated to publish it. The theory was sure, in 1655, to meet with incredulity and ridicule. He therefore had recourse to a device common enough at the time, though it seems somewhat absurd now, and published an anagram or cipher which contained the mixed letters of a Latin sentence stating that Saturn "is

THE GORGEOUS PAGEANTRY OF THE HEAVENS AS IT MUST APPEAR TO A WATCHER ON SATURN



THE SPLENDOUR OF THE EVENING SKY AS IT WOULD APPEAR TO AN OBSERVER FROM THE LATITUDE OF LONDON IF LONDON WERE ON SATURN

The diagram below this drawing by Mr. G. F. Morrell shows both the relative sizes and distances of each unit of Saturn's system as compared with that of the earth and moon

encircled by a thin, flat ring, not cohering with the planet at any point, and inclined to the ecliptic." Further study convinced him that his theory was invulnerable, and in 1659 he gave his discovery to the world, proving it at the same time by predicting accurately the phases the rings would present in the following years.

The Italian Astronomer in Paris who Showed that Saturn has Two Distinct Rings

Giovanni Cassini, a learned Italian who had been appointed Astronomer Royal in Paris, and was the first director of the Paris Observatory, had made a great reputation by his discoveries with regard to Venus, Mars, and Jupiter's satellites before he made the next advance in the elucidation of Saturn's rings. He showed that there was not one ring, but two. A dark circle divides a narrower outer ring from a much broader inner ring. This dark ring was carefully studied by Cassini, Herschel, and others, until it was clearly shown to be not a dark circular marking on a single ring, but a definite space between two concentric rings. This dividing space is known as Cassini's Division. The inner and the outer rings are not of equal luminosity. Cassini compared them to polished silver and dull silver respectively, and the simile gives a very good idea of their comparative appearance.

Further examination of these rings has added to the complexity of the system. Johann Encke, a famous German astronomer and director of the Berlin Observatory, whose name is remembered chiefly in connection with a comet he discovered, pointed out in 1837 that the outer ring of Saturn is itself divided by another dark line, as broad but not so clearly defined as Cassini's line. Encke's line can only be made out with a powerful telescope, and under favourable conditions in the position of the planet and in the terrestrial atmosphere. It is evidently not a clear division right through the outer ring, but rather a line or area in which the ring is much thinner than elsewhere.

The Occasional Divisions in the Planet's Rings that are Not Permanent

A year later De Vico saw two more dark lines on the inner ring, but these markings were not permanent divisions. Of these and similar discoveries Sir Robert Ball remarks that "occasionally other divisions of the ring, both inner and outer, have been recorded. It may at all events be stated that no such divisions can be regarded as permanent features. Yet their existence has been so frequently enunciated by skilful observers that it is impossible to doubt that they have been sometimes seen."

Cassini's and Encke's discoveries were followed, in 1850, by another of a surprising nature. In that year, Professor Bond, of Cambridge, U.S.A., and William Dawes, an English astronomer, discovered at the same time, but independently, that Saturn has three rings, and not two as had hitherto been supposed. The third ring was observed to lie immediately within the inner of the two which were already known, and to occupy about half the space between that ring and Saturn's globe.

This "gauze ring" or "crape ring," as it is often called, because of its filmy and half-transparent texture, is very dark as compared with the two rings which surround it, and had escaped observation on that account. It was not, as some were inclined to suppose at the time, a new structure, for many drawings made by earlier astronomers showed clear traces of it, though its nature had not been recognised.

Is the Gauze, or Inside, Ring of Saturn Becoming More Visible?

It differs remarkably from the two outer rings, which have a solid appearance, although we know that they cannot really be solid, for the body of the planet can be seen clearly through this dusky ring. Sir Robert Ball is of opinion that the increasing facility with which the crape ring is seen is only partially due to the fact that astronomers have learned what to look for, and that there is a real change going on, by which this ring is becoming more substantial.

The equatorial diameter of the planet, as we have noted, is about 75,000 miles. The diameter of the whole ring system, to the outer edge of the outer ring, is about 168,000 miles. This outer ring is about 10,000 miles in breadth; then follows Cassini's division, the dark line or area, which is about 1600 miles wide; then the middle ring, with a width of about 16,500 miles; then, without any clear separation, the crape ring, about 10,000 miles in breadth; and lastly, a space of about 10,000 miles between the inner edge of the crape ring and the planet's globe. The breadth of the system of rings, from the outer edge of the outer ring to the inner edge of the crape ring, is somewhere between 36,000 and 37,000 miles.

The rings all lie in one plane—that is, the plane of Saturn's equator. They are very thin, having a thickness which probably does not exceed eighty miles. "If we were

to construct a model of them," says Professor Young, " on the scale of ten thousand miles to the inch, so that the outer one would be nearly seventeen inches in diameter, the thickness of an ordinary sheet of writing-paper would be about in due proportion." So thin are the rings that when they are presented edgewise to the earth they disappear altogether, except to a few of the greatest telescopes in the world.

The Unsolved Mystery of the Constitution of the Rings

No wonder the question of the constitution of Saturn's rings became one of the greatest puzzles in astronomy. Their vast expanse, their excessive thinness, their lightness, which is such that they have been compared to immaterial light, their evident opacity, so that they throw a shadow on the planet's globe, and, above all, the absence of any other structure in the heavens wherewith they can be compared, combine to deepen their mystery.

Astronomers soon realised that solid rings were out of the question. In the first place, solid rings would be in a position of unstable equilibrium; for, as soon as the rings should shift in the least degree nearer to the planet at one point than at another, there would be a greater pull of gravity on that point, and the rings would fall in to the surface of the globe. And in the second place, even though equilibrium should be maintained, each ring would be like a stupendous arch built across the heavens; and no material that is at all conceivable could stand the crushing stress of the weight of the arch.

Nor would the centrifugal force developed by the swift rotation of the rings, however great it might be, really relieve solid structures of these dimensions from strains and stresses which would immediately shatter them; for centrifugal force would be greater at the outer edges of the rings than at their inner edges, while, conversely, gravitation would pull more heavily on the inner than on the outer edges. Nothing that we know could save solid rings from instant disruption.

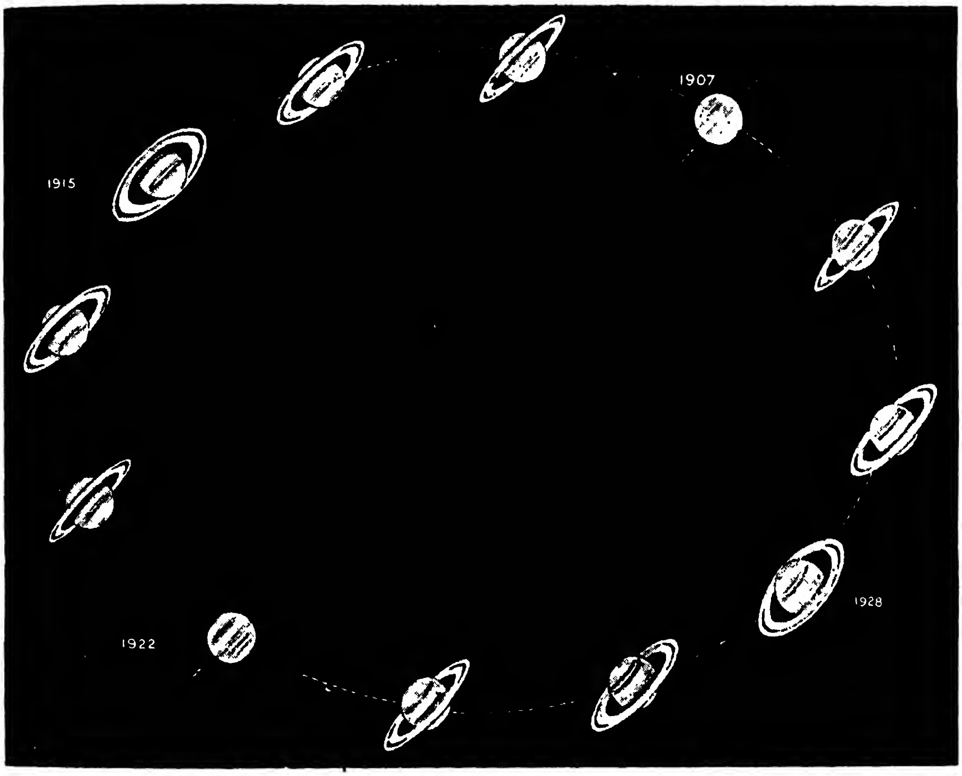
The Theory of Separate Particles, that Challenges the Fewest Objections

As an alternative to solid rings, it was early suggested that they might perhaps be fluid, but mathematical investigation showed that violent wave-motions would inevitably be set up in the fluid rings, and would quickly destroy them. But the exclusion of these impossible theories leaves us with only one possibility which has long held the universal assent of the scientific world The rings are made up of innumerable entirely separate particles. As to the size and nature of these particles we know nothing. But whether they average the size of the motes of dust which dance in a sunbeam, or, as Clark Maxwell suggested, are like brickbats, or whether they are as big as houses or as mountains, each of them is really on its own account an independent satellite of Saturn. This only possible explanation of the rings of Saturn was suggested by Cassini, nearly at the beginning of the eighteenth century, but it received little attention until the discovery of the half-transparent crape ring, which was evidently, at a glance, no continuous body, whether solid or fluid. The remarkable divisions between the rings still, however, remained a mystery. Why should this immense swarm of meteors which incessantly circulate round Saturn separate into three distinct rings? And why should the outer ring show a partial cleavage in what is known as Encke's division?

Why Should Space be Swept Clear Here and There?

When meteors are all round, and are moving freely, and are doubtless continually jostling and colliding with one another, what unseen force sweeps them out of the sixteen-hundred-mile-wide area of Cassini's division? Here the only possible answer was first suggested by the American astronomer Professor Kirkwood. The reader may perhaps remember that similar clean-swept spaces are found amid the intricate tangle of the orbits of the asteroids, and that the unseen influence there at work is the gravitative power of the giant Jupiter. Any asteroid pursuing an orbit within one of these spaces would be circling round the sun in a period commensurable with the period of Jupiter in his orbit. That is to say, it would complete its circuit exactly twice in the time which Jupiter takes to revolve once round the sun, or would perform five revolutions for two of Jupiter's revolutions, or by some other simple arithmetical relation of this kind would frequently be subjected, at the same point in its orbit, to the same pull from Jupiter. The result would be that any such asteroid would be pulled out of the orbit in which it synchronised with Jupiter into another orbit in which it would no longer be subjected to a constantly recurring pull in the same direction. A precisely similar influence has been at work upon the myriad meteors of Saturn's rings, sweeping

Cassini's division wholly clear of meteors, and Encke's division perhaps only partially clear of them. In this case, however, the disturbing agency has not been another planet, but has been the major satellites of Saturn himself, or, rather, the three inner satellites, which, being the nearest to the rings of meteors, have had the greatest influence upon them. Mathematical calculations show that the satellites known as Mimas, Enceladus, and Tethys revolve round Saturn in periods which are precisely commensurate with the periods of under the disturbing influence of the satellites, and driving many of them out of the proper plane of the rings. He points out that the knots or beads on the rings appear "exactly inside the points where the satellites' disturbing action is greatest, or, in other words, in precisely their theoretic place." It should perhaps be said that these appearances described as knots or beads are swellings extending all round the outer edge of each ring, and only appear as beads because they are seen in cross-section when we view the rings edgewise. The more



THE DIFFERENT PHASES OF SATURN'S RINGS AS SEEN FROM THE EARTH IN THE COURSE OF ITS TWENTY NINE AND A HALF YEARS' JOURNEY ROUND THE SUN

any meteors which should occupy the spaces or divisions between the rings. The three rings are due to these three satellites.

Another result of their influence is seen in certain knots or swellings which are observed on the rings when Saturn presents them edgewise to the earth. It is then apparent that the rings are not, after all, of the same thickness all through, but that the inner edge of each ring is thin and flat, while the outer edge is swollen to a considerably greater thickness. Professor Lowell explains this formation as due to collisions taking place between the crowded meteors frequent view of the rings, which shows their northern or their southern surfaces more or less foreshortened, does not show the thickening of their outer edges.

So far as is known at present, Saturn has ten satellites. The first was discovered by Huygens, who solved the problem of the rings; Cassini found four more; Herschel two more; an eighth satellite was discovered in 1848 simultaneously by Professor Bond, of Cambridge, U.S.A., and Lassell, an English observer; and the ninth and tenth were found in 1898 and 1904 by Professor Pickering, by photography.

THE MAGNIFICENT FÉE GLACIER, AS VIEWED FROM THE EGGINER RIDGE, SWITZERLAND

JOURNEYINGS OF THE ICE

How the Glaciers, as Travellers, Burden-Bearers, Engineers, and Engravers, Tell the Story of the Past

GLACIAL CREEPINGS NOW AND LONG AGO

Rivers of ice, like rivers of water, do a certain amount of carrying and carving. As a glacier crawls down from the mountains to the plains, it carries on its back a burden of boulders, and stones, and soil. All the way down it digs away at the hillside, and brings down upon itself a load of rubble. Rain, and avalanches, and little landslips serve to increase the load, and ultimately there are two long stripes or ridges of débris, one to the right and one to the left. These ridges of débris are known as lateral moraines. When two glaciers unite, their two contiguous lateral moraines unite, and take up a central position on the conjoint glacier, making what is called a median moraine. Usually toward the end of a glacier the lateral and median moraines are no longer distinguishable, and the stones and débris are scattered broadcast. Attached to the under surface of a glacier there is also a certain amount of soil and stones, forming what is called the moraine profonde. When a glacier melts and retreats it deposits the collection of stones and soil that has accumulated at its end, and this deposit is known as a terminal moraine, and shows where a glacier once has been, long after the glacier has melted away.

The amount of débris thus transported by a glacier may be very large, for to such a leviathan as a glacier no rock is too heavy. The moraines may form ramparts as much as 80 or 100 ft. high, and individual blocks may measure thousands of cubic yards. In the Valley of Saas there is a boulder of serpentine 1000 cubic yards in bulk. The stone named the Pierre-à-Bot measures 40,000 cubic feet, and must weigh about 3000 tons. It is 50 feet long, 40 feet high, and 20 feet wide. Yet it must have been carried sixty or seventy miles, and in all probability crossed the Lake of Neuchâtel. The Pflugstein, near Zurich, 60 feet high, 72,000 cubic feet in volume, and 4500 tons in weight, must have come across Lake Zurich from the Alps of Glarus. Near Monthey, in the Lower Valais, there is a belt of granite boulders, known as the Blocks of Monthey, which stretches for miles above the left bank of the Rhône, near its junction with Lake Geneva. These boulders must have come from the Valley of Ferret, thirty or forty miles away; and one of them, named the Pierre des Marmottes, is 60 feet long, 30 high, and 33 wide, with a cubic area, therefore, of about 55,000 feet.

Yet larger blocks, the Pierre-du-Trésor, near Orsières, and the Bloc-Monstre, near Devent, measure about 90,000 cubic feet and 130,000 cubic feet respectively. All the so-called erratic boulders are believed to have been carried by glaciers; and there are thousands of such "erratics" all over the world.

Quite apart from such prodigies, the amount of material borne by glaciers as moraines may be very large; and if the glacier has been alternately advancing in summer and retreating in winter, a terminal moraine may represent the deposit of many years. In some cases, there are several heaped-up terminal moraines, one behind the other, showing that the glacier has retreated or advanced intermittently. In North Italy terminal moraines are found which rise out of the plains of Piedmont as mountains 1500 or 2000 feet high.

The moraine profonde in the case of most mountain glaciers is quite inconsiderable, and little more than a smear of mud and a sprinkling of stones; but in the great Polar glaciers the amount of detritus carried along as moraine profonde may be immense. In all the Greenland glaciers there is a moraine profonde 100 or 150 feet thick, consisting of clay, earth, stones

and sometimes large boulders, scattered through the glacier ice. In the lowest 12 or 15 feet the whole glacier seems to be composed of black débris. In the Spitzbergen glaciers the same condition obtains. When glaciers of this type diminish or disappear they leave their track covered with earth and stones resembling the "boulder clay" and glacial drift found in various parts of Europe and America. Round the Booming Glacier, in Spitzbergen, where it has shrunk from larger dimensions, there are some square miles of tough mud which, if dried, would exactly resemble boulder clay.

The Tremendous Pressure with which Glaciers Grind the Hardest Rocks

As we said, glaciers both carry and carve. Such enormous, weighty, moving Juggernauts must crush and grind as they move along, especially as they often, if not always, have sand and stones and rocks embedded in their lower surface. A glacier 300 mètres thick presses with a weight of something like 486,000 pounds on every square yard of its bed; and though it may grind slowly, yet it grinds exceeding small. Even the hardest rocks are filed down and scored with scratches and ruts; and any collection of rocks which have been under the glacier present characteristic rounded forms like a flock of lying-down sheep, or like the backs of plunging dolphins. Rocks rounded by glaciers into such rounded forms are known as roches moutonnées, since De Saussure, who first described them, compared them to well-dressed fleeces, or the wigs styled in his day, moutonnées. Sometimes roches moutonnées are polished and smooth, but more often they are scratched.

The Part Glaciers Play in Remoulding the Surface of the Earth

That glaciers can do so much is certain; and the only question is, how much more can they do? They can rub away rocks undoubtedly, but can they gouge out valleys? And are their valley-making efforts to be compared with the achievements of rivers? On this question there is some difference of opinion. Some hold that such huge excavations as the beds of the Swiss lakes and of the great Canadian lakes were delved by glaciers; others consider the glaciers quite incapable of such big excavating work. On the whole, it is improbable that glaciers have delved on such a large scale; they act rather as planes than as spades, and the deeper lake-beds and deeper mountain valleys are not their work.

Whatever work glaciers do effect, they are aided, to a great extent, by the streams that issue from and flow with them. The water which flows from the lower end of a glacier is always muddy, and the mud represents a considerable amount of wear and tear, but wear and tear produced, perhaps, as much by the water as by the hard heel of the ice. Dr. Heim calculates that the débris "removed annually by all the Justedal glaciers, in Norway, is equal to a cube of rock measuring 134½ feet on each side." And it has been calculated that during the month of August the stream issuing from the Aar glacier carries away 280 tons of sand daily.

The water that flows down through the crevasses of glaciers, and drills a hole or moulin through the ice to the underlying rock, often wears out the rock into gigantic potholes, known as giants' kettles; and where these are found we may be sure a glacier has been. Near Lucerne several of these potholes were found in soft sandstone rock, some being several yards deep and several yards in circumference, and many of them are to be seen in Norway and North Germany.

How the Supernatural was Called on to Account for the Most Natural Forces

Such, then, is the work of modern glaciers, but there have been times when glaciers have been much busier than now, and a record of their travels is to be found in many lands. At one time, indeed, glaciers seem to have spread over the greater part of the Northern hemisphere.

This is generally recognised now, but it was not even suspected till quite modern times; and it was really the big erratic boulders we have already mentioned that gave the hint to geologists. For years the "erratics" had been a problem and puzzle. No one could say how they came to be distributed in such a strange fashion. No one could say how such massive boulders had been carried such great distances, often up hill and down dale.

The unlearned, feeling that the boulders required some explanation, fell back upon the supernatural, and usually came to the conclusion that the devil had had a hand in it, and had been using the stones as quoits, or marbles, or putting-stones. The erratic boulder, for instance, known as the Teufelstein, which lies by the side of the road on the St. Gothard Pass, is supposed to have been dropped there by the devil, who had tried to carry it across the valley for a wager. Such imaginative explanations,

GLACIERS THAT CREEP FROM MONT BLANC

MONT BLANC, THE HEAD AND SOURCE OF THE MER DE GLACE

THE END OF THE GLACIER DES BOSSONS, SHOWING ITS TERMINAL MORAINE

however, did not quite satisfy geologists, and they sought hard to find an adequate scientific explanation.

At first it was thought possible that great explosions or great deluges had lifted and dispersed them. But explosions could hardly fling stones weighing 3000 tons a distance of 60 or 70 miles; nor could a deluge, however tremenduous, carry a boulder up hill and down dale, over one hill into another valley, as erratics are often carried. Efforts to explain their transport by icebergs and floating ice were equally unsuccessful; and until seventy or eighty years ago no one thought of transport by glacier. In the first decades of last century the idea began to dawn, and the story of its dawning is very interesting.

In 1815, Jean de Charpentier, director of the mineral baths at Bex, spent a night in the cottage of a chamois-hunter of the name of Perraudin; and in the course of a conversation about glaciers Perraudin stated that the glaciers "had formerly a much larger extent than at present. Our whole valley was occupied by a vast glacier extending as far as Martigny, as is proved by the boulders found in the vicinity of this town, and which are far too large for the water to have carried them thither."

In 1829, a Swiss engineer named Venetz, who had been investigating the glaciers of the Swiss Alps, expressed his belief to De Charpentier that the whole Valais had been formerly the bed of an enormous glacier, more than 180 miles in length, and that this glacier had carried to the Jura blocks from the Alps.

The idea fell in good soil. De Charpentier thought over the mountaineer's and engineer's ideas, and finally communicated them as a scientific theory to a meeting of Swiss naturalists at Lucerne. So bold and revolutionary was the theory that it met with great opposition. But a true theory will always find champions as well as enemies; and two young naturalists, Louis Agassiz and Carl Schimper, not only championed it, but developed out of it the greater theory of a Glacial Epoch. It was the logical outcome of the chamois-hunter's common sense.

If it required a glacier to carry the boulders to Martigny, it required glaciers to carry the boulders from the Alps to the Jura mountains, and to transport all the other erratics that were found in other localities.

Further, all over Northern Europe and Northern America, ice had left its marks not only in erratic boulders, but in ruts and scratches and moraines, and roches moutonnées, and boulder clay, and "devils' punch-bowls." The more the matter was studied, the more certain it became that Northern Europe and Northern America had once been under an ice-cap.

GLACIER-POLISHED ROCKS IN ARCTIC NORWAY

The evidence pointing to a glacial period is only circumstantial evidence, but it is many-sided, and absolutely conclusive.

Let us look, for instance, at the composition of boulder clay, or "till," as it is sometimes called. It consists of an exceedingly tough, tenacious clay, mixed with grit, pebbles, stones, and rocks in varying amounts. The clay has evidently been subjected to great compression, and is so tough and compact that it is very difficult to excavate, and in some cases requires to be blasted with dynamite. The quantity and quality of the hard material in the clay vary considerably. Sometimes there are only a few stones sprinkled here and there; sometimes it is almost all stones together. As a rule, there is more clay than stony material. The stones in the clay vary much in size—they may be inches, or feet, or yards in circumference. As a rule, they are from two to eight inches in diameter. Large or small

SCOTTISH SIGNS OF A GREAT ICE-AGE

SINUOUS MORAINE BORDERING ON LOCH CLAIR, IN ROSS

MORAINES AND MORAINIC MATERIAL, WITH BEN EIGHE, ROSS, IN THE DISTANCE

The photographs on these pages are by Mrs. Aubrey le Blond, D. Macleish, G. R. Ballance, and others.

are mixed higgledy-piggledy together. Now, it is obviously a very curious thing that stones of such varying sizes should be mixed up with clay in this way, like the raisins in a plum-pudding. How did it come about? Who stirred the pudding?

At one time it was thought to be the work of a deluge, and was even taken as a proof of the Flood. But a deluge would have sorted out the material, as the waves sort out the pebbles in the shingle of a beach; and not a single instance has even been known of boulder clay deposits after a deluge—after such a deluge, for instance, as was caused in Bengal by the Backerzunge cyclone. Neither running water nor tidal water, neither river nor sea, could have have made the boulder clay mixture, but only the white pestles of the glaciers mashing up stones and mud in the mortars of the mountains and valleys.

ROCKS TRAVELLING ON A GLACIER

Further, when we examine the stones and pebbles in the boulder clay, we find that they are not oval and round like stones and pebbles that have been rolled in rivers and on sea-beaches; they are rather flattened and angular, with rounded angles, and they are scratched with scratches running usually parallel to their long axis. We do not find such scratches on stones which have been tossed and tumbled in rivers and oceans. On the contrary, these are polished and smooth; and we must regard the scratches as the authentic signature of glaciers. The stones, moreover, show no weathered crust; they show no signs of chemical erosion by water and air; they are quite sound and unoxidised, as if they had been just blasted from a quarry. All these facts point conclusively to glacial action.

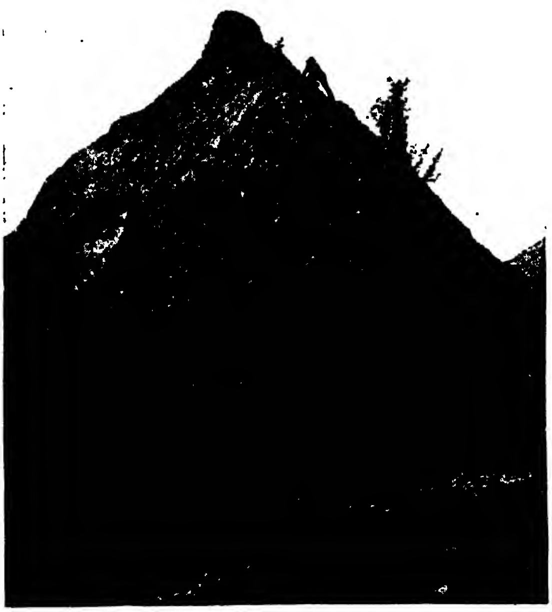
But we can go further still. If we clear the boulder clay off the underlying rocks, we find that the rocks are all scratched and grooved. The scratches are fine, as if produced by sand, but some of the grooves are wide enough for toboggan runs, and yet they all point the same way. What other graving-tool save a glacier could have made such markings? Over the island of Bute went the glacier, and all over the island the rocks are scratched from north or north-east to south or south-west, showing the direction of the glacier's flow. Moreover, we find that the marking instrument has managed to scratch not only the prominences and bulges of the rocks, but has marked the bottom of every dimple and depression. Again, what graving-tool save a glacier could have done it? The sea could not have done it; rain and wind and frost could not have done it. The work is undoubtedly the work of moving ice, whose polishing-powder contained both sand and rocks.

Again, in some places boulder clay is a thin layer; in other places it may be a hundred feet deep, and in some places it may be more than five hundred feet deep, but over any area covered with boulder clay the depth varies in an irregular way, quite independently of the nature and height of the ground. This irregularity of deposition is characteristic of a glacier, and could have been effected by no other natural agent. Yet, again, the rocks and stones mixed in the boulder clay are usually not all local: a certain percentage of the stones come from a distance of some miles. Only a glacier could account for this mixture. Only glaciers could form the roches-moutonnées, which are not in the least like rocks worn by rain and frost and rivers.

Finally, to make assurance doubly sure, we find in the boulder clay the shells of Arctic seas. Towards the end of the Tertiary Epoch, the climate of the world

seems gradually to have become cooler. During the greater part of that epoch the world was warmer than it is now, as is shown to us by the nature of its flora and fauna. The flora was sub-tropical; the fauna included such animals as elephants, rhinoceroses, hippopotamuses, hyænas, sabre-toothed tigers, apes. But towards its close the climate became much more severe, and we find that herds of reindeers wandered southwards as far as the Riviera and Switzerland, and that Arctic shellfish found their way into European seas. Colder and colder grew the earth; further and further south came the ice, till England was a mass of glaciers, and an ice-sheet stretched between England and the Continent. Down from the mountains of Norway crept the ice and snow. Now Russia was buried under it, now Northern Germany, now Northern France. In Switzerland colossal glaciers filled the mountain valleys and flowed across the plains. The Rhône glacier invaded France, and from the southern side of the Alps tremendous glaciers descended upon Italy, leaving on the plains of Lombardy the mighty moraines we have already mentioned. The Pyrenees, the Apennines, the Carpathians, the Balkans, the Urals, the Caucasus, even the Atlas Mountains and the mountains of Corsica, were heavy with glaciers. According to Dr. Hooker, the famous cedars of Lebanon grow on the moraines of former glaciers. Asia had not quite her share of the snow and ice, but Siberia was ice-bound; glaciers descended from the northern Urals to the plains of Obi, and the Himalayas must have been white almost to their base. In North America the ice extended as far as latitude 38 or 40, the north-eastern half being particularly affected, while, strangely enough, Alaska escaped. Altogether, an area of 4,000,000 square miles was under an ice-sheet, chiefly the plains of Canada and the upper Mississippi valley. Even tropical lands had to face an Ice Age. The snow-line crept thousands of feet down their high mountains; and mountains that had never known snow were capped with ice and burdened with glaciers. In the Southern hemisphere the glacial epoch was less severe. Still, Patagonia, New Zealand, Australia, Tasmania, all had some experience of it.

We have spoken of the Ice Age, but the Ice Age was not continuous: it probably consisted of several glacial periods, with periods of milder climate between, when the ice retreated from the boulder clay.



AN ERRATIC IN ARCTIC NORWAY

If we examine a thick deposit of boulder clay, we find that it is not homogeneous, but that there are layers of finer clay and sand through it, and in these layers often remains of animals and trees. The natural inference is that these layers represent a time when the ice retreated from the earth and thus rendered it again habitable. Professor James Geikie, who made a special study of the Ice Age, was of the opinion that in Europe there were several alternations of glacial period and more temperate periods. After the first glacial period, there came a great thaw and very genial climatic conditions. The climate of Europe, indeed, though not so warm as in the Tertiary Epoch, was warmer than now, and over England there roamed elephants, rhinoceroses, and hippopotamuses. For thousands of years there was this period of genial warmth, and then again came the snow and ice, with a consequent change in the fauna and flora. Icebergs drifted as far as the Azores, and Arctic species of molluscs flourished round the coasts of Sicily and Italy. Again a thaw. At first the boggy land grew only lichen and moss and coarse

grass, and the fauna consisted of reindeer, woolly rhinoceroses, musk-ox, and gluttons, but by and by, as a good climate persisted, the vegetation became more luxuriant, and elephants, and deer, and lions, and leopards appeared.

Gradually again the climate deteriorated, gradually Arctic flora and fauna reappeared, and a third glacial epoch set in. This epoch was not quite so rigorous as the second, but still Britain and a great part of Northern Europe were buried under ice. In time a third inter-glacial epoch followed, but this time no elephants and hippopotamuses appeared, and the dominant feature of the vegetation was widespread forest. Still a fourth glacial epoch followed, to be succeeded by a fourth inter-glacial period, characterised, like the third, by a great growth of forests. Not even yet was the climate settled; a fifth glacial period supervened, and there were various climatic oscillations before the climatic conditions that now prevail were established.

In America there were at least as many oscillations of heat and cold. During the whole glacial period there were various submergences and emergences of the land. When the ice invasion was most extensive, it is probable that the northern parts of Europe and of North America were much more elevated than now. Arctic shells that live at a depth of 30 to 90 feet have been found 1330 fathoms deep in the clay of the North Atlantic, which would seem indubitably to indicate that the North-West of Europe must have once stood about 7000 or 8000 feet higher than it now stands, and that a tremendous subsidence took place in the Northern hemisphere after the time of maximum glaciation.

From this subsidence the Northern hemisphere never quite recovered, but marine shells found in Wales and Cheshire at a height of over 1200 feet, and in the Scotch hills at a height of 500 feet, and in the valley of the Saskatchewan at a height of 1900 feet, show that re-emergence of the land did to some extent take place. The cause of the rise and fall—or rather of the fall and rise—is uncertain. Some attribute the submersion to the weight of the ice, and the emergence to the removal of the weight by the melting of the ice, but it is more likely that there were movements in the earth's crust quite apart from ice pressure.

All through these wild and wintry times the wonderful creature man managed to survive. He came to the earth just before this Age of Ice, and he lived through it all. He saw the great ice-rivers overwhelming the meadows and the plains. He saw the solid earth sink below the sea, he saw the mountains rise again. He knew Britain as part of a great continent when the Thames was a tributary of the Rhine; he knew it as a cluster of little icy islets. He hunted the reindeer among the Alps and pursued the

A MEDIAN MORAINE AT THE JUNCTION OF THE GORNER, BREITHORN, AND LYSKAMM GLACIERS

mammoth and lion in the forests of England. All these changes and hardships he survived.

The cause of the Ice Age is unknown. About twenty years ago, James Croll endeavoured to show that it was due mainly to the indirect effects of an increased eccentricity of the earth's axis. With the sun farther away from the earth in winter, he thought that a colder and snowier winter would ensue in temperate latitudes, and that the winter snow would persist through the summer, and give rise to fogs which would intercept the summer sun. The trade winds and the ocean currents would consequently be altered, and the cumulative effect would be a genial epoch alternately in the Northern and Southern hemisphere. Afterwards Sir Robert Ball supported the same theory, but it did not stand the test of critical examination, and it is now almost completely given up by expert geologists.

AN ICE GROTTO UNDER A GLACIER IN GREENLAND, SHOWING RUNNING WATER IN THE SPRING

Attempts have also been made by Chamberlin and Arrhenius to explain the glacial epoch on the basis of variations in the amount of carbon dioxide in the atmosphere. A little more or a little less carbon dioxide, by diminishing or increasing radiation of heat, would have important climatic consequences, but the theory has not yet been worked out in all its details, and it is not certain that this alteration would be competent by itself to produce the glacial and inter-glacial periods. Still a third attempt has been made to explain the Ice Age on the basis of geographical changes such as elevation of a vast area of land, with deflection of warm air and warm ocean currents. No doubt such geographical changes would produce climatic alterations, but the theory is still quite inchoate. Altogether we must confess that no adequate scientific explanation of the Ice Age has yet been found.

THE FINDEL GLACIER FORMING A LAKE, WITHIN VIEW OF THE MATTERHORN AND RIFFELHORN

THE STATUARY GROUP OUTSIDE THE PASTEUR INSTITUTE IN PARIS, SHOWING THE ATTACK OF A WOLF ON THE SHEPHERD BOY WHO WAS THE FIRST PATIENT FOR HYDROPHOBIA

ON THE MICROBE'S TRACK

The Fascinating Life and Work of the World's Greatest Chemist Louis Pasteur

MAN'S SUPREME PHYSICAL BENEFACTOR

We now come to the name of a great man, seldom thought of as a biologist, to whom, nevertheless, the science of life is immensely indebted, and who must certainly rank beside any of those whose work we have already discussed. Similarly, we shall find that Louis Pasteur must rank with or above the greatest doctors of all time, though he was not a doctor. He holds a place apart, at the foundation of many modern sciences, for none of which was he educated or specially prepared. For he began life as a chemist, and all his subsequent researches really spring from a chemical view of the problems of biology and medicine.

Early in our study of life we saw that there are processes of fermentation which play a large part in it, but how large no one can know who has not followed the work of the last few years. There are some who say that "life is a series of fermentations," which is probably true of the physical processes associated with life. Plainly, then, we want to know what fermentation is. When Pasteur began his work the dominant view was that of the great chemist Liebig, who was some twenty years his senior. His theory was that fermentation is a chemical phenomenon, due to certain chemical agents, called ferments, probably acting in association with the oxygen of the air.

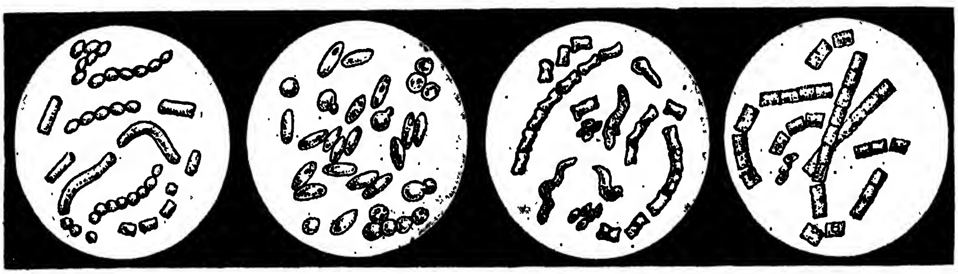
Then there came upon the scene the young Pasteur (1822-1895), who was trained as a chemist in Paris, under some of the greatest chemists of the day. His genius for original research showed itself at once. The first piece of work he did was upon the behaviour of crystalline salts of tartaric acid. Students of optics know that it is possible to "polarise" light in such a way that all its vibrations are in one plane, instead of being in all planes at right angles to the onward path of the light. It is found that, when a ray of such polarised light is sent through certain substances, they twist or rotate the plane of the vibrations, sometimes to the right, and sometimes to the left. Such substances are called, respectively, "dextro-rotatory" and "lævo-rotatory." Ordinary tartrates have no influence on polarised light, and are said to be optically inert; but the young Pasteur found that a certain microbe (the familiar word was introduced by him) feeds upon or ferments a solution of tartrates in such a way that they become "lævo-rotatory," or "left-handed," as we often say. The solution, he discovered, began by being a mixture of the two kinds, right-handed and left-handed, in such proportions that the ray of light was not rotated in either direction on passing through them. But the microbe ferments the "right-handed" molecules, so that the solution now becomes "lævo-rotatory," or "left-handed." This is a true fermentation, and it is effected by a living plant. That was Pasteur's initial discovery; and all the rest, including the triumphs of Listerian surgery and many great things yet to come, flow from it.

Let us briefly note, in passing, what this discovery meant for chemistry itself, for recent developments of it may serve biology as much as anything which we are about to study. Pasteur showed that the molecule of tartaric acid may exist in two forms, exactly identical, except that one is, so to say, the mirror-image of the other. They differ, in a word, just as a right hand does from a left. This gives us the idea of chemical molecules as *solid* things, existing in three dimensions, and requiring to be studied from the point of view of their solid shape, as well as of their constitution. Hence Pasteur's initial discovery founded what is now called "stereo-chemistry"—that is, *solid* chemistry—which is beginning to win great triumphs. Its aid is essential in the realms of organic

chemistry, and without it we could not achieve the synthesis or creation of new compounds, such as "606," and a host of other therapeutic substances. It may make all the difference in the world—or, rather, in the body—that a compound is built up on a left-handed rather than a right-handed plan; and once we realise that our chemical processes are a series of fermentations, and that one and the same ferment may destroy a right-handed compound and leave its mirror-image untouched, as Pasteur showed, we begin to see light upon many of the problems of disease.

The fundamental fact discovered by Pasteur was, of course, the presence of a living agent in this fermentation. Liebig believed that fermentation was a chemical phenomenon, but Pasteur's work showed that it was a vital phenomenon—a living agent was involved. Nowadays, we see that, in a sense, any opposition between these two views was unreal, for we can often extract a chemical ferment, not itself alive, from the bodies of microbes, and can prove that this ferment does its work in the absence of actual life. Thus, the "vital theory" of fermentation, as upheld by Pasteur, does not really exclude the "chemical theory," upheld by Liebig. But the cardinal fact remains that these ferments are produced in the body and by the life of a living thing. Fermentation, then, may be due—perhaps is always due in Nature—to the growth and life and chemical activity of microbes. It is not the air that causes fermentation, though the process may be arrested in materials from which air is excluded. The exposure to air is really exposure to microbic infection, and the fermentation follows. Or, if air be necessary for fermentation, it is because air is necessary for the growth of most microbes, but it is the microbes, and not the air, that are really responsible.

To the great alarm of his teachers, Pasteur turned at once from the orthodox paths of chemistry, and devoted himself to further investigation of the ways of microbes. It seemed by no means certain that these microscopic objects really existed, or mattered, if they did; and, in any case, what possible fruit could be expected from the study of them? But Pasteur held on his way. He showed that, while all microbes, like all living things, require oxygen for the purpose of respiration, some obtain it from the air, whereas others cannot live in the presence of air, but obtain their oxygen from their food—the oxygen—containing compounds which they split up in the course of their lives. The air-needing microbes he called aërobic, and the others anaërobic. The former will grow most abundantly upon the surface of any culture-medium, whereas the latter will only grow at some distance beneath the surface. A typical instance of the anaërobic bacteria—discovered long afterwards—is the bacillus of tetanus, or lockjaw, which grows in the soil and may thus infect any chance wound in the hand of a gardener, without relevance to whether or not the wound be in the space between the thumb and first finger, as is popularly supposed. But the great majority of wounds infected with soil fail to give rise to tetanus, because the microbe, disliking the air, can flourish only several inches below the surface.



MICROBES THAT BEFRIEND MAN BY PROCESSES INVISIBLE TO HIS EYE

The small microbes at the top of the first circle make milk sour, those below them help in the making of butter and cream. In the second circle are the yeast organisms, which make alcohol. In the third circle are the microbes that make vinegar, and in the last circle are the microbes that make cheese.

Pasteur soon showed that the change in the optical activity of tartaric acid did not stand alone in being due to microbes. He found that the production of lactic acid, from lactose or sugar of milk, is also due to fermentation by a microbe, the *bacillus lacticus*. He showed, also, that the formation of butyric acid in rancid butter is due to certain bacteria, mostly anaërobic. He found the same form in the very important case of acetic acid, which is produced from ethyl alcohol by the action of the *bacillus aceticus*. This was a matter of very great practical value. By his study of these

processes, occurring in wine and vinegar, Pasteur was able to formulate very useful rules for the making of vinegar, and also to give effective directions for the prevention of "wine disease." This last phrase begins to suggest the kind of work to which the latter part of Pasteur's life was to be devoted, for more important things than wine are subject to disease.

But first there was a very much discussed problem to which Pasteur's attention was directed, and which is certainly a biological problem. This was the question of the origin of life, which we discussed in the second chapter of this section. Here we shall distinguish between the conclusions which were drawn from Pasteur's work, and the work itself. All we are entitled to say is that Pasteur's experiments refuted the supposed proofs of spontaneous generation which many accepted at that time. Materials which had been deprived of life—or sterilised, as we now say—were found to remain as they were indefinitely, provided that no life from outside had access to them. They did not ferment, and no life appeared in them, no matter how suitable for the composition or generation of living beings they might be. Hence it followed, and still follows, that if spontaneous generation of life can occur or does occur at the present time, the conditions under which it does so are still unknown.

Not the least useful result of this controversy was the occasion it provided for a great many observations on the vital conditions of microbes. Only by experiment can we ascertain what temperatures microbes will survive or succumb to, and what chemical substances, in what proportions, will arrest their growth, and so act as preservatives of fermentable materials, or, to use the modern term, as antiseptics. It was in the course of this work that Pasteur discovered the method of sterilising milk which is now known as pasteurisation, and consists in the prolonged employment of a less degree of heat than will be effective if used for only a short time.

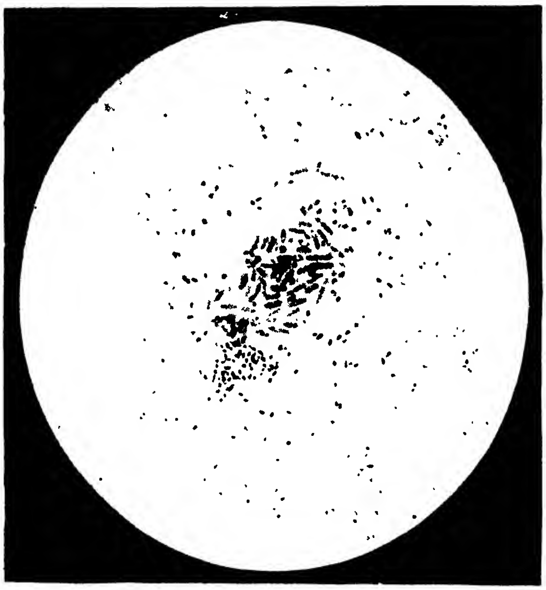
THE EXAMINATION OF A CULTURE OF MICROBES IN A TEST TUBE

In the 'sixties, after his study of the silkworm disease, by which he was enabled to save one of the most important of French industries, Pasteur began to find that certain microbes are not merely saprophytic but parasitic, living within the tissues of other living creatures, and producing disease. Fowl-cholera matters little to us, but his work upon the anthrax bacillus, which produces the disease called anthrax not only in certain animals but

also in man, was truly epoch-making, for this was the first demonstration of a microbe as the cause of a human disease. Needless to say, the word "cause" has a very definite meaning. Many have asserted, and perhaps one or two may still survive who assert, that the presence of these microbes of various kinds in various diseases is only an accompaniment or concomitant, but not a cause. It might be that the microbe, though certainly parasitic, did not really do any harm, but was merely enabled to grow in the tissues of the host in consequence of the change produced in them by the disease. This would conceivably account for the presence of special types in constant association with special forms of disease—in each case the patient's body, on this theory, is made a suitable soil for the growth of some particular microbe. At the stage when the existence of microbes can no longer be denied, and when they are found to be definitely associated with certain diseases, this explanation may be advanced.

If it be true, of course it reduces the presence of the microbes to an accident of no importance, and the real cause of the disease remains to be discovered in each case. The criticism thus advanced is highly necessary and salutary, for there are many instances where certain forms of microbes seem to be found, perhaps constantly, in association with certain forms of disease, and have been put down as their causes, though the probability is that their presence is secondary and of no importance. This is probably true, for instance, of various microbes which have been described at various times as the causes of malignant growth.

Therefore, when we say that Pasteur found microbes to be the causes of disease, in many instances, we require to cite the necessary evidence, which has always been complied with in those cases, such as anthrax, where science now accepts the evidence. First, there must be no case of the disease in the absence of the alleged cause; the association between the symptoms and what is asserted to be the causative parasite must be absolutely constant. This must not be also read in the converse sense, to mean that the symptoms must appear wherever the parasite is found. The parasite may be quiescent or inert, or its poisons may be so neutralised by the body that the symptoms do not appear. But, certainly, if the parasite causes the disease, it must always be found when the disease is present.



BACILLI OF ANTHRAX FORMING SPORES

Constant association is thus a necessity for the proof, but it is not enough, for it proves nothing as to causation. The presence of the parasite, as we have seen, may be the effect and not the cause of the disease. It is necessary, therefore, to show that the parasite, when introduced into a normal, healthy animal, produces the disease in it. Very often this experiment may fail, for the animal may be immune, and no symptoms follow. But if the parasite is really the cause of the disease, it will be found to produce the characteristic symptoms, at any rate sometimes, when introduced into the tissues of other individuals of the same species as that to which the first victim belongs. We should now be able to recover the parasite from the body of the second victim, and to show that it has multiplied therein, while producing the symptoms we have observed.

This may seem sufficient, but even now we have not absolutely proved that the parasite is the cause of the disease. In transferring it from the sick to the sound we are, of course, unable to isolate it in such a fashion that no fluid accompanies it. Hence, it may be argued that the parasite, thus transferred—we say parasite for convenience, but the number would probably

be millions--was not the cause of the symptoms in the second victim, but that they were produced by the really efficient agency of some special poison in the fluid which was taken from the first victim, and which happened also to convey the parasite. That was a theory which required consideration in the past, and must be mentioned now, but it is negatived by innumerable facts which have been ascertained during the past half-century. In fact, we shall see that Pasteur's next research was in itself sufficient to show that the parasite, in such a case as anthrax, is really the cause of the disease.

Meanwhile, we are to observe the nature of the evidence which science must always require before we can say that a given parasite is the cause of a given disease. So constantly have bacteriologists been misled in the past that we must take warning. First, we repeat, the parasite must be found in all cases of the disease. This may be no easy matter, for by no means all bacilli are as large and readily detected as that of anthrax. In some forms of tuberculosis, for instance, the bacillus of that disease cannot be found, though material from the diseased parts will transfer the disease. Here the reason is that the bacilli have assumed a form, the so-called spore-stage, in which they cannot be observed by the ordinary means. Second, we must not be disconcerted if we find "pathogenic," or disease-producing, microbes in cases where no disease is being produced by them. At an early stage in our knowledge, such observations would have been most disconcerting. If it has been laid down that a certain coccus causes pneumonia, and a certain bacillus causes diphtheria, what are we to say when these organisms are found in the throats of persons who are in perfect health?

Photograph by LOUIS PASTEUR Pierre Petit

The answer, we now know, is that the accepted use of the words "pathogenic" and "non-pathogenic," as if microbes could thus absolutely be distinguished, is erroneous. We have clear evidence, for instance, that certain "pathogenic" microbes, such as those we have mentioned, may exist in the body and not be pathogenic. We are certain, also, that microbes commonly reckoned non-pathogenic may sometimes take on pathogenic action. This complicates our argument, but does not invalidate it. The fact is that microbes may behave in different ways at different times, according to the conditions of their nurture, as we shall see. Further, the soil must be reckoned with.

We now know that, for instance, there are people called typhoid-carriers, who constantly harbour the typhoid bacillus within them. But for some personal reason they do not suffer from typhoid fever. They are in perfect health; and we might argue, as used so often to be argued, that the case against the so-called typhoid bacillus, as the cause of typhoid fever, therefore breaks down. But unfortunately the fact is that if these bacilli, from such a typhoid-carrier, get a chance of invading someone else they promptly set up typhoid fever. If such a typhoid-carrier has such a profession as that of a cook, her life-history may involve a long train of hitherto incomprehensible deaths on the part of those for whom she has worked; and only very lately has the strange but simple explanation been worked out.

These and many other instances are teaching modern bacteriologists that the

supposed distinction between pathogenic and non-pathogenic bacteria must either be abolished from our vocabulary or recognised in a new way. These terms are purely relative to the circumstances. A man may harbour pneumo-cocci in his throat for weeks without hurt, and then lie drunk on the road all night, and next day he will be starting with pneumonia. The cold and the alcohol have lowered his resistance—whatever that means in terms of exact chemistry—in such a fashion that the formerly innocuous cocci initiate a deadly disease. Henceforth, then, we shall try to realise that the problem of disease-production is a complicated one, with many factors, and it cannot be stated simply in terms of the seed, for instance, without any reference to the soil. The seed itself, also, offers a host of problems on account of its variability in behaviour. Its successive generations succeed one another with extraordinary speed, sometimes as often as three times in an hour; and in the course of a short time of exposure to certain conditions a race or strain that began in a condition of extreme virulence may be rendered quite harmless, or *vice versâ*.

We are to understand that these parasites, unlike some of the larger animal-parasites of man, do not produce their effects by their mere presence. Their action depends upon the production of a chemical product which we may call their virus or poison. The question, then, is as to the virulence of any particular microbe, according to the abundance and quality of the virus it produces. This requires very close study, and it is not enough to judge by effects, for those effects introduce a new factor—the resistance of the new host. Thus a given culture, of a given virulence, whatever that may be, will kill one host in a few hours, and will produce no symptoms at all in a second. Are we to judge of the virulence of this culture by the first experiment or by the second? The fact is that the first host was susceptible; and the second, perhaps having lately recovered from an attack of the same kind, was, for the time being, at any rate, immune. We have to distinguish, then, between results which are due to changes in the seed, and those which are due to the varying conditions of the soil.

THE BACILLI OF DIPHTHERIA

When we do so, we find that the microbes themselves can be caused to vary widely in virulence, so that they can no longer do any harm to creatures which would otherwise certainly have succumbed. Pasteur himself was the pioneer in these researches, which have already produced tremendous results for the benefit of man and of animals. He had no sooner begun his great observations on the anthrax bacillus than he proceeded to study the effect upon it of many agencies. This, of course, is work of a kind which can never be finished, for there is no end to the experiments that can be made as to the action of, say, sunlight, radium, Röntgen rays, new drugs, and so forth upon all manner of microbes. Pasteur soon found that the virulence of microbes is modified by exposure to air, by the conditions of their nutriment, by varying temperature, and so forth. Thus if anthrax bacilli be grown at a high temperature for twenty-four days they lose their virulence, and can no longer kill a sheep. This was the basis of Pasteur's method of immunising animals against anthrax. He injected these attenuated bacilli, as they are called, into a sheep, and in this way such a resistance was somehow acquired by the animal that, when it was inoculated, a fortnight later, with a culture which had been exposed to heat for only twelve days, and was therefore only half as attenuated, presumably, as the first, the animal did not suffer. A fortnight later an injection of the ordinary virulent, unattenuated bacilli

produced no ill-results. The animal had been rendered immune by a gradual process of cell-education, which was made possible by the discovery of a method of attenuating the bacilli by means of heat. This now celebrated method is applicable also to cattle and horses, and has now been in use for many years, having enormously reduced the mortality from anthrax.

But there is a more interesting and significant way in which the virulence of microbes can be attenuated. Just as growth at something well above what is called its *optimum* temperature will weaken a microbe, so growth in the body of an animal of one species will commonly weaken or attenuate it, so far as animals of other species are concerned. The rule seems to be that the microbe adapts itself to the special conditions, and thus loses its suitability for other conditions. Thus Pasteur found that the parasite of swine plague, when inoculated from rabbit to rabbit, increased in virulence for rabbits, but was attenuated for pigs. Organisms which had been passed through a series of rabbits produced in the pig illness, but not death; and after this illness the pig remained immune to parasites of ordinary virulence for at least a year.

THE MICROBES OF ERYSIPELAS

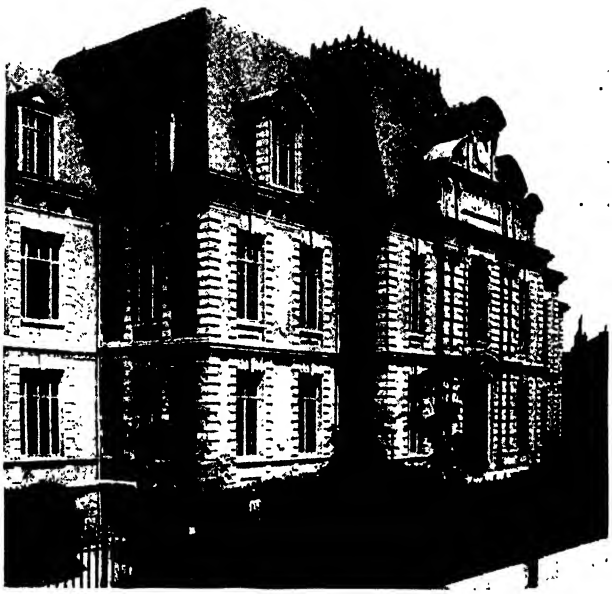
Pasteur's observations led to the discovery of the general principle that the virulence of a parasite for one species is diminished by its growth in another; and that thus vaccines, as they are called, may be obtained which will induce a mild attack of illness in a member of the other species, *such as will protect that individual.* The reason why we call such substances vaccines is evident. Clearly this process, invented by Pasteur with certain parasites he could identify, is the same as that invented long before his day by Edward Jenner, for the case of smallpox, the parasite of which is still unknown. No modern student of disease doubts that what we call smallpox in ourselves, and what we call vaccinia in the cow, are one and the same disease, produced by the same parasite in both cases. But the growth of this parasite in the bovine species attenuates its virulence so far as we are concerned, and thus, when we are vaccinated, we suffer from so mild a form of smallpox that it cannot even be called smallpox, but it will protect us from that disease for years.

Lady Mary Wortley Montagu introduced into this country from the East—her husband was ambassador at Constantinople—the practice of inoculation for smallpox. This meant actual inoculation from mild human cases. Many deaths resulted, but the survivors were usually immune for life. Vaccination, properly carried out, causes no deaths, and does not produce such long-maintained immunity; and it acts by the method of inducing a mild attack by parasites attenuated by growth in another species—the method which Pasteur was the first to elucidate.

Just as the virulence of microbes can be attenuated, by such various means as we have mentioned, so also it can be exalted. This is most easily done by the method of *passage* discovered by Pasteur, and illustrated in the case of swine-fever and rabbits. As the organism is passed on from one susceptible animal to another, it increases in virulence, and this explains the fact, often observed, that epidemics increase in deadliness as they advance, for the later victims of the infection are attacked by parasites whose virulence is exalted by passage through the earlier patients. It has also been found that the virulence of a parasite is usually increased when some other parasite, or its poison, is injected at the same time. The resistance of the host is reduced, and the parasite can thus grow freely and increase in virulence. This is an observation of extreme importance in all

forms of tuberculosis, where dirty surgery, neglect, and exposure to foul atmospheres and dust are very liable to introduce other infections, which most gravely complicate the case—largely, as we may now guess, because the virulence of the bacillus of tuberculosis is enhanced under such pre-eminently unfavourable conditions.

At least as famous as any other research of Pasteur's, though not so far-reaching in its consequences, is his work upon hydrophobia, or rabies, a disease of which the causal parasite is still unknown. His results were published in 1885, after a long series of most complicated researches, calling for every great scientific quality of mind. At last, by following the principles already mentioned, he was able to provide himself with preparations which contained the virus of hydrophobia in what may be called its normal strength, and in forms attenuated and exalted. These were contained in the nervous tissues, brain, and spinal cord of animals of various kinds, for Pasteur found that the virus is always most abundant in nervous tissues. No doubt the living parasite of the disease was, and is, contained in such preparations, but we have never yet seen it, and it may be ultra-microscopic. With these preparations Pasteur sought to act on human beings who had been bitten by mad dogs, availing himself of the comparatively long period of incubation in man, which is usually about forty days, but may be much longer. The first case treated was that of a young shepherd boy who had been bitten by a wolf; and his statue, representing him in the act of trying to defend himself from the animal, now stands outside the Pasteur Institute in Paris. This patient received a series of injections, from the spinal cords of rabbits, each successively being made from a cord of greater and greater virulence. Immunity was thus induced, and the dreadful symptoms of hydrophobia never appeared.



THE PASTEUR INSTITUTE, IN PARIS

It is, of course, a legitimate and necessary objection to the claims made for this method that the patient may not have been infected in the first place. Thus the Pasteur Institute does well to estimate its results only in terms of patients bitten by dogs proved to have had rabies, by inoculation of healthy animals with parts of their nervous system. In the year of Pasteur's death, 1895, 122 cases of this class were so treated, without a death. The ordinary mortality was 16 per cent. of persons bitten, who would include a good many bitten by dogs not really mad. The results have steadily improved, and have been similarly obtained by Pasteur Institutes in many parts of the world—other parts of France, Italy, Russia, and elsewhere. In Paris now those who have carried on Pasteur's work since his death have attained such perfection that the mortality, which was less than 5 per cent. in the ten years preceding Pasteur's death, has been reduced to practically nothing at all, with the sole exception, as Professor Metchnikoff has pointed out, of a few persons suffering from chronic alcoholism, in whom the process of immunisation has been impossible of attainment.

Thirteen years ago, two of the most distinguished pathologists in this country wrote the following words: "It may now be taken as established that a very grave responsibility rests on those concerned if a person bitten by a mad animal is not subjected to the Pasteur treatment." And those words may be repeated today, with all this additional experience behind them. Fortunately, however, in this country, the

beneficially stern muzzling order of Mr. Walter Long, and our regulations regarding animals at our ports, have freed us from one of the most appalling and ghastly of all diseases.

Such, in very brief outline, is the life-work of Louis Pasteur, but centuries must pass before all its fruits can be told. His body lies in a little chapel under the Pasteur Institute in Paris, and his countrymen hold him in the highest honour. Of all physical benefactors of mankind, since the dawn of time, this man is supreme—the founder of bacteriology and the father of preventive medicine. "It is in the power of man," he said, "to make all parasitic diseases disappear from the earth." He saves animals, soldiers, mothers alike, for in 1877 he discovered the microbe of childbed fever, now unknown wherever skilled and clean attention is available for motherhood. He was remarkable in the annals of science as a devout Catholic, and was fond of saying "Tout est miracle," a remark worthy of recollection by those who think that science has made all things plain, because they have lately learnt a fraction of what Pasteur discovered.

Such men as he are the saviours and makers of the world. We have no formula for their construction, in classrooms or elsewhere. We can only be grateful when Life vouchsafes them to us, and learn to give them the opportunities they need, and to apply their knowledge to the practical problems that face mankind. If democracy is to triumph, it must be because it grows tired of false gods, famous for an hour, and then infamous for ever; tired of the theory that life-serving truth can be found by counting noses or crosses in a ballot-box: and sets itself to favour and help and value and be guided by such men as Louis Pasteur.


THE TOMB OF LOUIS PASTEUR IN THE CHAPEL IN THE PASTEUR INSTITUTE, PARIS

THE ORGAN WITH WHICH THE BEE SUCKS

The proboscis or tongue of the honey bee—of which the end portion is shown here highly magnified—is a hollow organ filled with fluid and terminating in a "bouton" or spoon. The nectar gathered from a flower by the bouton passes up the flexible under surface of the tongue in a groove, which is surrounded by thickened skin and formed into a tube by numerous fine hairs. The nectar then enters the pharynx, and passes, mixed with saliva, into the honey-bag, where it is changed into honey.

The photographs on these pages are by Mr. J. J. Ward and Messrs. Hinkins and Son.

FRIENDS OF PLANT LIFE

Attractions Offered by Flowers to Birds and Insects, and the Value of Their Visits

MUTUAL SERVICES BY PLANT AND ANIMAL

If one were asked what aspect of plant life makes the most popular appeal to the admiration and æsthetic delight of men, one can hardly doubt that the answer must be the relationship between plants and their friends of the animal creation.

The artist delights in depicting his floral conceptions with a gaily coloured butterfly fluttering in the neighbourhood; and every children's book that deals with the animate creation will be found to contain some pictures drawing attention to the interesting partnership between flowers and butterflies, or flowers and birds. It is these processes in connection with plant life that have always appealed most to the non-scientific observer, but they are equally interesting to the careful student of the physiology of plants.

If one were to inquire from an entomologist, who devotes his energies to the study of the habits of insects, he would inform us that many of the structures displayed in the bodies of these little creatures are very obviously adapted for the special purpose of bringing them into close adaptation with the forms of particular flowers. If, on the other hand, we were to seek the opinion of the botanist, who looks at similar biological problems from the standpoint of the plant, he would express a no less definite opinion that a very large number of flowers exhibit structures and qualities obviously designed to bring them into intimate relationship with the size and habits of an equally large number of insects. Both observers would be perfectly correct, for the inter-relationship is a very definite one, and essential to both sides. Huge numbers of flower-seeking insects would certainly vanish from the list of living creatures if the flowers they affect were to fail to bloom for a single season.

Not only insects, however, but other creatures, and more particularly birds, also have a very intimate relationship with plant life, and play a very important part in its successful development. We shall return to this point later, but may state at the outset that there is no more flagrant example of the colossal harm done by equally colossal ignorance than in connection with this very subject of the relationship between birds and plants. It is too sadly true that the great majority of people whose pleasure is in their gardens are hopelessly convinced—hopelessly, because ignorantly—that the greatest enemies of plant life are birds. Hence, they have conceived it to be their duty to shoot and snare and otherwise destroy every bird that ventures its presence, even if only in the hope of picking up a worm. As a matter of fact, the services the birds render to their friends the flowers are infinitely valuable; and nothing but wilful ignorance of the part birds play in this connection could possibly account for—but not, of course, extenuate—the cruelty practised.

It would almost seem as if the morphological variations to be found in the flowering plants could be made to correspond in size and shape and design with all the varied visitors, from the tiny little midges at one end of the scale, through the beetles and butterflies and bees, up to the birds, all of whom, by means of their various organs, either extract some of their food from the flowers, and in so doing brush off the pollen, or feed upon insect pests on the plant itself.

Still further evidence of the extremely interesting and close partnership between these two parts of living things is to be found in observing how the appearance of certain flowers corresponds, in point of time and season, with a similar appearance of certain butterflies and insects. With the

advent of spring the appearance of the butterflies is welcome, as they escape from their cocoons; and, simultaneously, almost to the day and hour, the first spring flowers open their petals to the sunshine. True, the casual observer may notice the butterfly and not the flower, or *vice-versâ*, according to his personal mental habit, but the interesting thing is that the two coincide. And just in the same way, at the very moment almost, when the bees emerge from their hibernating period, and are ready to search the world for honey—and, incidentally, to scatter pollen—does the willow-catkin open in readiness for their visits. The observer may notice the one event or the other, but the really interesting thing is to realise that the two have an interdependence in the world of Nature.

So, also, if we notice the hourly habits of certain insects and butterflies, we shall find interesting plant connections. There are flowers that are only wide open in the early part of the day, and these have for their sole visitors butterflies which are nocturnal in their habits and active at the same time that the flower opens, flowers and insects both retiring for the night at the same time.

The Relations Between the Moths that Fly and the Flowers that Open at Night

On the other hand, other flowers open wide at sunset, after the activity of the butterflies is past. Are they, then, left without means of pollen distribution? By no means. In the place of the butterfly come various kinds of moths, fluttering about in the glimmering twilight, moths which remain obscure and unnoticed in dark and lonely nooks throughout the sunshine, just as the flower declined to show its face until the evening light. Once more one observer will notice the hawk-moth, or other species, becoming busy, and another will draw attention to the fact that certain flowers are opening after sunset. But, again, we say that the really interesting thing is that these two appearances are mutually interdependent, and have an important relationship to the lives of both plants and animal.

In such a huge subject, and one so fascinating as this, it is absolutely necessary to confine our attention to one or two definite points, and those the most important. Let us endeavour to be quite clear as to what it is, in the first place, which renders the visits of insects and birds to flowering plants necessary or attractive; and, in the second place, see what advantage is to be gained either to the insect or bird, on the one hand, or to the flower, on the other, by such repeated visitations. There must be some definite reason behind it all. Phenomena of this kind do not occur with such definite regularity in Nature except for some particular purpose.

The answer to the first question is that insects visit plants, in the first place, in search of food for themselves—it is not a question of any altruism, but merely of self-preservation. Sometimes the insect will creep into a plant by way of seeking shelter; and sometimes it chooses that situation in which to deposit, or protect, its young ones.

The Mutual Services that Flower and Insect Confer Upon Each Other

The primary guiding principle, however, is certainly the search for food. The absence of the altruistic principle in this stage of the scale of creation makes it imperative that the flower shall demand some service in return for the food or the shelter it gives to the visiting insect. Both insect and flower are in search of individual advantage, not endeavouring to confer favours. The plant, therefore, develops structures of such a nature that, should an insect succeed in carrying off the pollen of the flower around which it intends to feed, it can only do so if, at the same time, it transfers some of it from one flower to another as it makes its repeated visits to different individuals of the same species. In this way is secured what is called cross-fertilisation or cross-pollination of flowers by insects, and this is the service and advantage rendered by the insect to the flower as a payment for the food supplied by the latter.

The Discovery by Charles Darwin of the Value of Cross-Fertilisation

It used to be supposed by the older botanists that all that was necessary to ensure perfectly satisfactory fertilisation in plants was that the pollen from one flower should be placed upon the stigma of another of the same plant. It was not, however, until Charles Darwin, in 1857 and 1858, in his work on "Cross and Self Fertilisation in the Vegetable Kingdom," drew attention to the fact that *some plants* were entirely dependent for their fertilisation on pollen being transferred from one to another that the value of cross-fertilisation became recognised. From his own labours, and those of his fellow-botanists, it was soon ascertained that almost all the flowers which exhibit brilliant colours and delicious odours, or are otherwise attractive and conspicuous, flourish far better when, instead of being fertilised by their own pollen, they secure pollen from

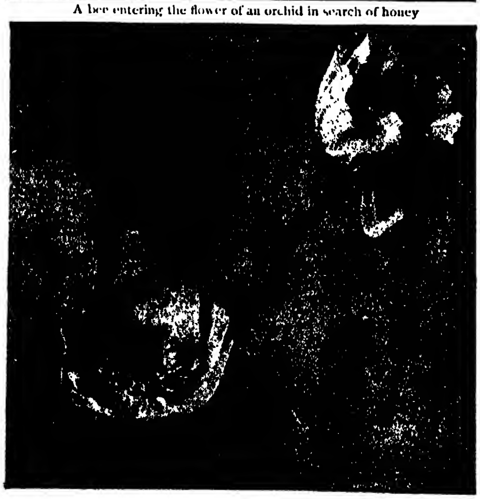
THE BEE AS A FERTILISER OF FLOWERS

The petal of the iris, showing the bright lines that guide insects to the nectar

A bee seeking honey and receiving on its back pollen from stigmas of iris

A bee entering the flower of an orchid in search of honey

The bee withdrawing from the orchid, bearing yellow pollen on its back



A bee collecting honey and receiving pollen from a yellow poppy

Stigmas of cornflower spreading pollen on the sides of a bee as it sucks

PHOTOGRAPHS IN COLOUR OF THE TRANSFERENCE OF POLLEN TO THE BEES BY FLOWERS

Photographs by F. Martin Duncan

other flowers of their own species. This fact was then established by actual experiment, simply by treating a flower by its own pollen and treating another flower of the same kind with pollen from another individual. The result was that the number and vitality of the seeds which resulted was much greater in the case of the cross-pollination than it was in the case of the self-pollination

It is a very short step from this to the realising of the fact that most plants which succeed best when cross-pollinated depend upon the visits of insects for the effecting of that cross-pollination; and it may be stated as a broad general rule that nearly all the conspicuous colours and markings and scents exhibited in so many flowers are nothing more nor less than so many signposts pointing the way to the store of nectar of which the insects are in search, or to the exact position of the pollen, as the case may be.

Few people realise to what a great extent many insects depend entirely upon the nectar of flowers, or the pollen of flowers, for their food supply. It is usual in such cases to find that the insect goes from flower to flower of one particular species, at any rate, throughout any one given journey, and the result of this is that it carries about with it the pollen of that particular species, and that alone, thus most effectively cross-pollinating that plant Just as the plant holds out advertisements, so to speak, attracting the attention of visitors to the food supply to be obtained in the nectar and the pollen, so many of the insects have developed special structures in order to take advantage of the corresponding parts of flowers. It is quite obvious that, in order to be of much service in cross-pollination, there must be some means whereby the pollen adheres to the body of the visitor. In other words, there must be something that enables the visitor to carry away as much pollen as possible for his own purposes, and, incidentally, for those of the plant. For this reason some beetles and ants which are often found on plants are practically of no use from the point of view of pollination, because their bodies are smooth. But it is very different in the case of moths and all the butterflies, and in some of the beetles, as well as most of the bees, all of which have a sort of rough surface consisting of hairs or scales, on or among which quite a large quantity of pollen is deposited. For instance, in the common honey-bee most of the covering of the insect is distinctly hairy, and, not only so, but this creature has on its hind legs special receptacles which carry quite a large quantity of pollen as the bee goes on its round. This pollen is, of course, intended by the bee for food, and as such is a dead

THE HIND LEG OF THE WORKER BEE
This micro-photograph shows, above the claws and pads of the foot, the pollen brush, consisting of rows of stiff hairs, and above it the pollen basket, also provided with strong hairs.

loss to the plant. It so happens that there very bees, which collect so much pollen for themselves, are exactly the species which are most pertinacious in visiting flowers, and so it follows that the pollen that adheres to their hairy backs is carried from flower to flower of the same species, so that the species gains as much as it loses. No better example could be adduced of the mutual relationship between the two.

We have said that the principal attractions held out by flowers as an inducement for insects, butterflies, moths, etc., to visit them are nectar, the scents, and the attractive colouring of the petals, or other organs. A very commonly held but erroneous idea is that the nectar in flowers is identical with the honey; but, as a matter of fact, the nectar which is secreted by the nectaries is a preliminary stage in the formation of honey. The honey is only truly produced after the nectar of the flower is partly digested by the bee. These nectaries, or nectar-producing glands, are structures which are generally placed near the base of the flower, and after the flowers have secreted their nectar the latter is frequently found adhering to the surface of the gland in minute droplets. In other cases it is carefully stored away in special receptacles, which are the true nectaries, perhaps the most common example being seen in the ordinary columbine petal. The secretion of some kind of substance of this nature is to be found in the vast majority of flowers visited either by insects or birds, and the constituent that is the real attraction is the sugar in it. In appearance the secretion varies very much, being sometimes quite watery and without colour, and at other times distinctly dark in tint, the odour, as a rule, being similar to the odour of honey

ONE OF THE TUBES OF A BUTTERFLY'S TONGUE, PARTLY UNCOILED

Great variety exists in the means that make it easy for the visiting creature to obtain the nectar of which it is in search. In some cases it is quite obviously exposed, and so is readily accessible to all and sundry. A good deal, however, depends upon the structure of the insect itself as to whether it can carry away or feed upon the nectar available. For instance, we find on the ovaries of a good many plants—the ivy being an example—a coating of nectar which cannot be sucked up except by an insect with a long proboscis; whereas the nectar is precisely suited for the beetles and flies and gnats which have such probosces.

Of course, there are floral arrangements which induce exactly the opposite conditions — namely, those in which the nectar is carefully concealed in some special receptacle to which no insect having any but a short proboscis can gain access. These forms of nectar secretion are therefore particularly suitable to the bees and the butterfly and the small birds. The concealment of the nectar is contrived by some very ingenious arrangements, especially in the nature of flaps or coverings to the aperture of a tube, or by the tube itself closing by means of fleshy lips. In either of these cases the insect in search of the nectar is forced either to separate the lips which close the tube or to elevate the flap of tissue itself which is acting like a trap-door.

It is a well-known fact that the sense of smell is very acutely developed among the insect group, a fact sometimes painfully obvious in the housekeeper's larder. One has only to watch the number of flies attracted to a piece of meat covered over

ith netting or gauze, and the efforts they ake to penetrate this covering, not to ention the swarm of bees or wasps tracted to any sweet-smelling, sugary con-)ction such as jam. We can readily under- and, therefore, what an additional advan- ıge it would be to a flower, in its endeavour) secure cross-fertilisation by means of ısects, to possess an additional attraction ı the nature of scent.

It may be noted that most of the small owers, such as the mignonette, as well as ıost of the flowers which open in the even- ıg or at night, are provided with this ttraction of a sweet scent. That this ıkes the place of the attraction due to rilliant colouring may well be inferred

THE FLOWERS OF MONKSHOOD AND NASTURTIUM, SHOWING THE NECTARIES
ı the monkshood two of the flowers have been cut down to show the two nectaries normally hidden in the helmet-shaped calyx lobe

'om the fact that so many night-blooming owers are perfectly white in colour. The weet-scented tobacco-plant is a case in oint.

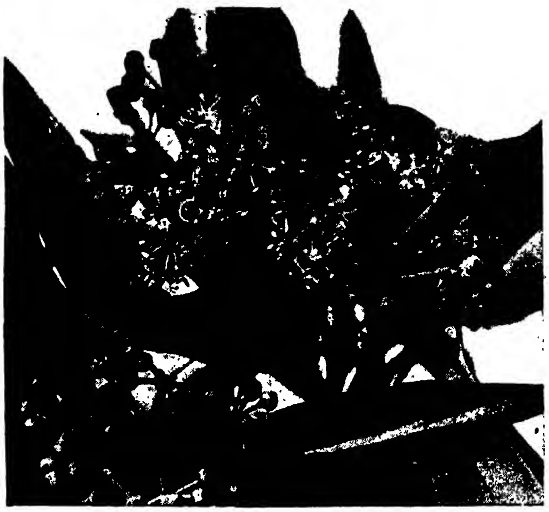
In a certain number of plants we find hat the flowers and their foliage have the ame smell; and here we may probably afely assume that the smell of the foliage just as protective to it from the attacks f grazing animals as it is attractive to ısects seeking nectar and pollen in the owers. Perhaps it is more common, owever, to find that the smell of the oliage varies from that of the flowers when oth are scented. Examples of this fact re to be found in the garlics, whose leaves mell like onions, but whose flowers have the scent of honey; and in the common hemlock, which has a distinctly disagreeable smell suggesting the presence of mice, but which, nevertheless, possesses a delicate scent in its flowers.

Of the variety of the scents themselves there is practically no end, and nothing is more difficult to describe except by using the name of the flower itself. To describe the scent of a rose, one is practically com- pelled to say simply that it smells of a rose, that mignonette smells of mignonette, and so forth. It has been stated that the number of floral scents that can be dis- tinguished is not less than five hundred.

In connection with the perception of the presence of scent by means of the organ of smell, it is necessary to be careful lest we assume that the insects which visit flowers on account of the smell do so because they are attracted by the scent appealing to nervous mechanisms similar to those which in man respond pleasurably to the stimulus of scent. As a matter of fact, the olfactory organ, as we find it in human beings, is certainly very different from the mechanism in insects that conveys to them the impression of a smell. For example, they have no struc- ture analogous to the mucous membrane, commonly regarded as essential to the human nasal organ. The question is a very complicated one, and cannot be dis- cussed here, but the point we wish to make is that it may very well be, indeed must be,

the case that great differences exist between the sense of smell as developed in human beings and in insects. It is quite possible, and quite likely, that some insects can smell the scent of one species of plant and entirely fail to detect the scent of another; and this probably explains why it is that some insects visit some flowers and avoid others. One may observe bees flying with great avidity to a Virginian creeper, whose flowers are perfectly inconspicuous, and to which they could only be attracted at a distance by the smell, which, to our organs of sensation, is not obvious. Apparently bees can smell the flowers of the plant just mentioned at a distance of not less than three hundred yards.

An example of the exquisite way in which insects and some flowers are adapted to help themselves is that seen in cases where the scent of the flower becomes obvious exactly at the time when the flight of certain insects begins. Some of the honeysuckles and petunias, which have a very faint smell, or none at all, during the day, are powerfully scented in the hours of the evening, at which time the particular insects which visit them get on the wing. The same thing is true of some of the pelargoniums, the visitors in this case being moths. As one might expect, many flowers which are acutely scented during the daytime, when the butterflies are visiting as well as the bees, become perfectly void of smell after sunset, when these insects disappear. One cannot, in short, doubt that the second great attraction a flower can offer in order to help its own cross-pollination is the possession of a scent or odour obvious, at least, to some insects, even if unperceived by man, and emitted during certain times of the day or season when particular insects can exhibit activity.



THE FLOWERS OF IVY

The third attraction we have mentioned is colour. This is a special instance illustrating a general principle, because, in order that any substance may be visible for a considerable distance, it is necessary that it should be brightly coloured. The principle is carried out in every sphere of daily life, from the hoardings in our streets to the signals of our ships and the targets for our rifles. No more brilliant forms of colouring are to be met with anywhere in Nature than in connection with flowers; and since most flowers are carried on green plants, in such a position that they are uppermost on the whole, we should expect to find the colours which predominate—if they are to be regarded as a means of attraction from a distance—are those that form striking contrasts to the predominating green colour of the plant itself. The arrangement of flower colouring, indeed, is largely a question of producing striking contrasts. These colours, as a matter of fact, are principally white, yellow, red, blue, violet, and brown. If one examines a number of flowers at a distance, it will be obvious that the white, the yellow, and the red form by far the most striking contrasts with the green foliage; the blue and violet tints are much less conspicuous, and the brown hardly visible unless close to the observer.

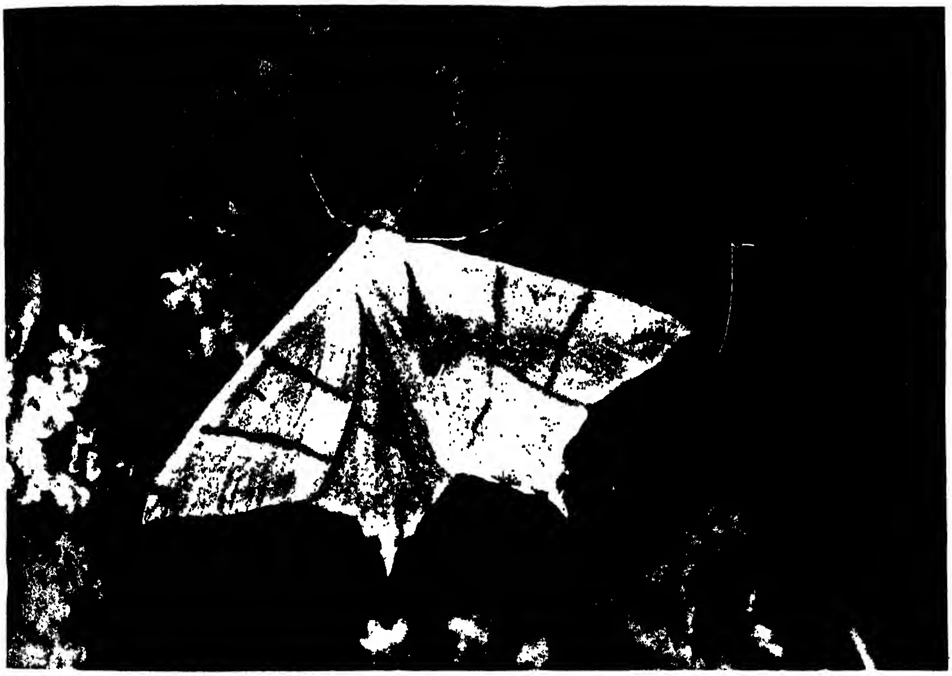
Most of the brilliant colouring matter of the flower designed to attract insects or birds is found in the petals themselves; and in almost every case the petal, or the side of the flower most exposed to an insect flying past, is that which is most brilliantly or attractively coloured. Sometimes, however, other parts of the flower are coloured equally brilliantly with the petals, and sometimes it is the outside or the inner side which is most conspicuous, but these anomalies are due to some peculiarity in the attitude of the flower itself.

Apparently different colours attract different insects. For example, flowers of a dull yellow, brownish, or purple colour are chiefly visited by certain kinds of flies, while the butterflies appear to be much more readily attracted by red, violet, or blue colour-schemes. Sir John Lubbock, in his book on "Flowers, Fruits, and Leaves," shows that bees have a distinct capacity to

distinguish between different colours, the experiment being conducted by placing portions of honey on glass, which, in its turn, was placed upon different coloured papers.

One cannot suppose, however, that the colouring of flowers constitutes as important a means of attraction to insects as does the odour, because, as a simple matter of fact, insects cannot see at a great distance. The range of even a butterfly and moth is probably limited to about five feet, while the bee and the wasp cannot distinguish objects further than two feet away, and the fly at a slightly longer range. It would be probably accurate to say that no insect could possibly be attracted by a colour at a greater distance than six feet from itself, whereas, on the other hand, as we have seen, the attractiveness of odour is evidenced for very much longer distances.

We have therefore the presence of nectar and pollen, scent, and colour as the three striking attractions of flowers for insects and bird visitors, the colour and scent pointing the way to the presence of the nectar and pollen. This, however, is not all, because, as may be observed by anyone who will take the trouble to look closely at any considerable variety of flowers in a garden, it is extremely common to find the petals of flowers so marked in stripes or dots, or in some other pattern forming a contrast to the rest of the petal, as to indicate exactly where the nectar is to be found. The lines of these markings are definite signposts, and doubtless point the way quite clearly to the insect visitors. Further, in order that the arrangement may secure the advantage required by the flower, it is designed that the insect travelling over these paths so clearly laid down for it becomes itself dusted with new pollen from the flower it is on, and leaves behind it other pollen which it has brought from a flower previously visited. Thus, by arrangements of mutual adaptation, is cross-pollination obtained with certainty. It is therefore not too much to say that a vast number of insects and birds are to be regarded as the truest friends of plant life, especially that portion of plant life which bears flowers. True, the plant flowers, or parts of them, must be also protected from injury from the insects and birds; but, this protection being secured, the fact remains that the services rendered to plants by insects and birds are absolutely invaluable, and it is a short-sighted policy, born of ignorance and folly, which attributes to insects and birds nothing but harm in a garden of flowers.



A MALE SWALLOW-TAIL MOTH SUCKING NECTAR, BY MEANS OF ITS LONG TONGUE, FROM THE DEPTHS OF AN ELDER-FLOWER

AN IMPOSTOR WHO APPEALS TO THE UNIVERSAL LOVE OF MYSTERY AND DANGER

THE CHARLATAN OF A DREADFUL TRADE, WHO IGNORES THE REPUGNANCE TO SNAKES, AND BY USE OF HIDEOUS CRUELTY PRETENDS TO BRAVE THEIR POISON

THE REVILED SNAKE TRIBE

Uncanny Survivals from the Earliest Ages of the World, and Inspirers of Terror in Man and Beast

MASTERS OF THE WORLD BUT FOR MAN

The common noun "reptile" has become an adjective, employed to characterise the basest, most malignant, and contemptible of qualities in human-kind. This is taking a very serious liberty with our elders. Before mammals emerged, with man as their crown and scourge, reptiles possessed the earth. From them sprang both mammals and birds. We vilify our own kin, descendants from our own ancestors, when we lightly designate as "reptile" an action which is inexpressibly repugnant. These humble, unloved creatures are of more ancient lineage than we, who in comparison with them are the parvenus of creation, the latest, as well as the highest. We have our Domesday Book, a work spanning little more than eight petty centuries; they have their Domesday Book, but it was engraved by the finger of Time itself upon strata whose age was one with that of the hills when man himself was yet to be, in a future then infinitely more remote than is his beginning from the present age.

Never before or since has the earth seen such weird, fantastic terrors as roamed the world when, in the great age of reptiles, cold-blooded, egg-laying giants parted the four quarters of the globe between them. The mind grows dizzy as it tries to conjure up the scene presented to the view when the world was in her youth. The dramatis personæ are part and parcel today of the rocks which man hews to make him a dwelling-place; and as we disinter them from their stony matrix we try to set them up again, petrified ghosts from out a dead age, in the manner in which they bore themselves. Some we set upon their mighty haunches, and some we represent as tiptoeing across a marshy world, like titanic culverts on colossal struts whose dry bones live. And the effect is that, as we learn more, we realise how little we really know. So we doubt.

We wonder today whether that fearsome diplodocus in our Natural History Musem ever had a prototype walking as that one is represented as walking. We ask ourselves whether, after all, the frightful original was not in the main aquatic; whether, upon coming to land, its enormous bulk did not cause those pillar-like limbs to straddle and to splay even as those of the noisome crocodile of today. We know how they produced their young—that in some cases these reptiles produced their progeny alive, the egg having been hatched within the mother's body. We know that because fossil remains have been found with the unborn young still within the ribs of the dam. We know something of their internal organism, from the curious markings upon fossil dejecta, which, first worn as charms and ornaments by modern women before the true origin of coprolites was ascertained, return, after treatment by the chemist, to renew the earth from which it sprang millions and millions of years ago. We know that some of these reptiles swallowed stones to aid digestion, as birds swallow grit and small stones today, because such millstones within a reptile's body have been discovered under circumstances which admit of no doubt as to their origin.

All this, and more, we know, and some of the results of our knowledge are set out at pages 49-50 of this work, but there is more that we do not know, nor ever shall learn. For Time has swept the originals, themselves and their type, into her charnel-house; and only an insignificant group of orders remain, numerous in genera and species, but limited actually to four orders in place of the eleven orders into which we have been able to classify the original

assemblage. Only these four linger today to contest the losing battle against man and the rest of the animal world. Two of those orders, the crocodiles, and the tortoises and turtles, have already been disposed of, in the chapter beginning at page 1887. Here we divide an order, and, separating the snakes from the lizards, address ourselves to the former.

Snakes and lizards belong to the same order; and, although there are no snakes which would be mistaken for lizards, there are lizards which the vast proportion of observers mistake for snakes. Even a hearty lover of animals shrinks, dubious and afraid, from a slow-worm, which, for all his marvellous mimicry of the snake, is the jolliest little lizard in the world. To shun the snake and the snake-like is natural, and the fear experienced by reasoning man in the presence of a snake is shared by our unreasoning cousins the apes. The attempt has been made to analyse the sense of terror which we thus experience. One authority holds that we inherit it from our ape-like ancestors; another terms it the dread of the unknown and unfamiliar, the mental attitude which sees a ghost in an unusual effect of moonlight, or makes a dog bark at his own shadow, or a horse shy at some strange object on the road. Be the origin what it may, the sense of horror inspired by the snake is real enough. A man in pursuit of water-birds in a South American swamp is suddenly brought face to face with a great female puma, which, in spite of all stories to the contrary of the friendliness of this animal towards man, instantly prepares to spring upon him. Without a tremor he aimed, fired, laid her dead at his feet, and went his way rejoicing. Next minute the same man, in forcing his way through the tangled undergrowth, nearly touched a snake coiled round a branch. "The effect was worse than an electric shock, and the perspiration rushed from every pore of my body as I sprang back in mortal terror, not knowing at the time that it was a harmless constrictor. The suffering of those few moments was greater than I could have experienced had the puma rent me to pieces. The nerves which enabled me to draw a steady sight upon that mass of muscular energy, prepared to launch itself with irresistible force upon me, were completely unstrung by the sight of a miserable reptile, whose back I could have broken with finger and thumb!"

THE POISON FANGS AND TONGUE OF A VENOMOUS SNAKE

Of course, this fear is not so blind and unreasoning in an educated man as it might be in an untutored savage, brought, for the first time in his life, into the presence of a serpent. The record of the snake is the worst of any living animal's, death-dealing insects alone excepted. We have no record of the deaths from snake-bite in Africa, Australia, and America, or the record would make appalling reading, but figures are kept as to India, where we lose every year, from this cause, enough citizens of the Empire to form a fair-sized town. Deaths from snake-bite in India have numbered during some recent years:

1905 ..	21,795
1907 ..	22,854
1908 ..	19,738
1909 ..	21,364
1910 ..	22,478

For every human life destroyed by a snake in India, five snakes are killed. Indeed, the total is far higher, for thousands are destroyed by sportsmen and others, whose kills do not appear in the records of that department of the Indian Government which awards payment for the destruction of the reptiles. Yet, in spite of all attempts to exterminate the pest, we find that the latest return is almost the heaviest of all. The reason is that high floods in Eastern Bengal and Assam drove the snakes into the raised village sites of the natives, where they destroyed their hosts.

It is conceivable that, were it not for the mastery of man, snakes might cover the earth; we might again have an age of reptiles. They have really very few enemies to fear. They possess weapons among the most formidable in the whole scale of animal nature. There is the poison of the venomous snake, capable of development on the side of virulence; there is the crushing

THE ANCIENT SYMBOLISM OF THE SNAKE

The snake, besides serving as the embodiment of evil, has played an important part in the faith of the past. In the earliest times it was specially associated with the practice of medicine. At the temple of Æsculapius, in Cos, snakes fed within the sacred precincts by a patient were supposed to exercise miraculous powers—one of the earliest illustrations of mind-cure operating on believing votaries.

power of the snakes which depend upon brute strength for the mastery of their prey. In saying that the virus of the snake is capable of still further lethal effect, we have this fact to go upon: that, preying upon cold-blooded fish, whose organism is necessarily less sensitive than that of a warm-blooded mammal, the sea-snakes are armed with a venom fifty times as powerful as that of the dreaded cobra. The killing power of the venom possessed by land-snakes could be increased, and the size of these reptiles could swept away the giants from which our contemporary reptiles have sprung would, in course of time, reduce the snakes—bulk and brains do not keep company. But the extinction of an order is not soon effected. The snakes, small-brained though they be, are a very numerous assemblage—more than 1600 distinct species have, up to now, been classified, and additions are constantly being made to the list. Although they merely crawl and wriggle and writhe, they have brought their method of progression to

AFRICAN NATIVES CARRYING A SIXTEEN-FOOT PYTHON

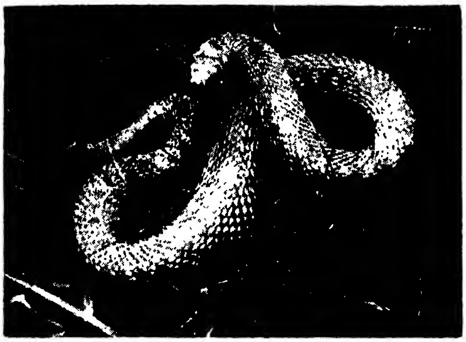
be enhanced, so that the serpents would be capable of grappling with still larger prey than is at present the case. And, seeing to what prodigious power and measurements the anacondas, greatest of all the constrictor snakes, have attained, it is conceivable that the pythons and other crushing snakes, huge enough already, might render their bulk still more formidable. The only check upon this development would be that imposed by Nature herself. The remorseless operation of the laws which

such perfection that they seem not to miss the legs which they have sacrificed. Climate limits their range, and seas shut them in, but their distribution and diversity of habit are remarkable. We have snakes which haunt the jungle and the reed-bed, the river and lake and marsh; which lurk in caverns; bury themselves, all but the head, in sand; which burrow like worms; others which climb trees with inimitable facility, which swim like eels, while some make their home entirely in the sea.

ANIMALS MOST DREADED BY MANKIND

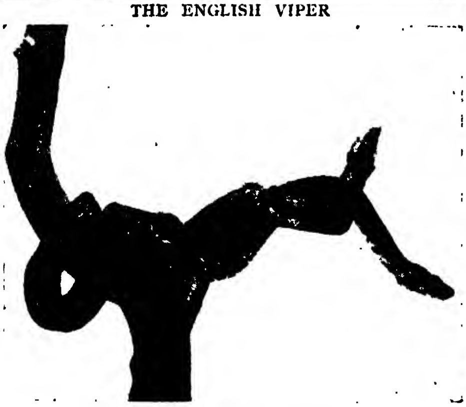
THE RATTLESNAKE OF NORTH AMERICA

THE DARK GREEN SNAKE OF SOUTH EUROPE

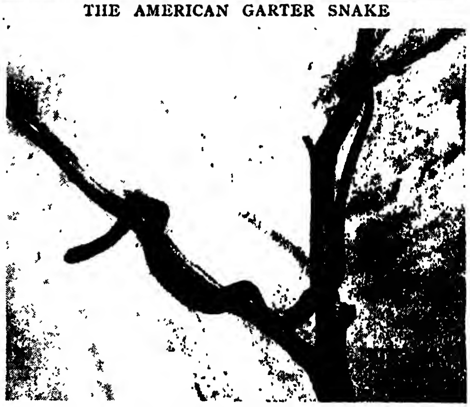


THE ENGLISH VIPER

THE AMERICAN GARTER SNAKE



THE INDIAN PYTHON



THE EUROPEAN GRASS SNAKE

THE KING-SNAKE

A YOUNG SOUTH AMERICAN ANACONDA

The photographs on these pages are by E. Ponting, C. G. Lane, L. Medland, P. Hanley, W. Berridge, Underwood & Underwood, and others.

Except for the Arctic and Antarctic regions proper, snakes are pretty well everywhere, with the exception of Ireland and Iceland.

For the man in the street the snakes fall into two divisions—snakes which are poisonous and snakes which are not. That is well enough so far as it goes, but we are not to understand that poisonous snakes form one related group, and non-poisonous snakes another. The fact is that the poisonous forms, together with certain non-poisonous groups, arise from a common stock. Every group of poisonous snakes has separately acquired its poison.

The mechanism of this poison apparatus is of interest. Let it be noted that snakes do not sting; to sting is the function of insects and jelly-fish. Snakes bite, whether poisonous or non-poisonous. The snakes which are non-poisonous possess four rows of teeth in the upper jaw; poisonous snakes frequently possess only two teeth in the upper jaw. Other teeth will be found in the upper jaw of the latter in all stages of development, but they are only "spares," as the motorist says. They are ready to take the place of those already in use, if and when these become broken or fall away from age. These two teeth are simply poisoned daggers, either channelled from the root to the tip, or hollow throughout their course, in order that they may conduct the venom from the sac in which it lies. In some the poison fangs may preserve the natural position of teeth when the mouth is closed, but in the majority of species the fangs fold back upon the gum when the mouth is shut, after the fashion of baleen in the mouth of the whale. When the mouth of the snake is opened to strike at a victim, the teeth are erected by a muscular movement which compresses the poison sac, causing the fatal fluid to pass down the channel either through the tooth or upon its grooved exterior. The fangs are driven into the victim's flesh, and, as they penetrate, the venom is injected as by a hypodermic syringe.

AN AUSTRALIAN SNAKE ROBBING A NEST

The result, as a rule, is death. Even the bite of our little English viper causes intense suffering, and not uncommonly death. The poison of the deadliest snake is held to be quite harmless if received by way of the mouth into the digestive system, but, introduced into the blood, it is as fatal as a bullet through the heart. When the poison has done its work, the snake eats its victim, unless the latter be too large. Its venom is mainly employed for destroying the creatures which are to form its meals. But as a snake must live to eat, it turns its frightful weapon against an intruder likely to injure it. This accounts for the number of deaths from snake-bite in India; not necessarily wanton aggression on the part of the snake.

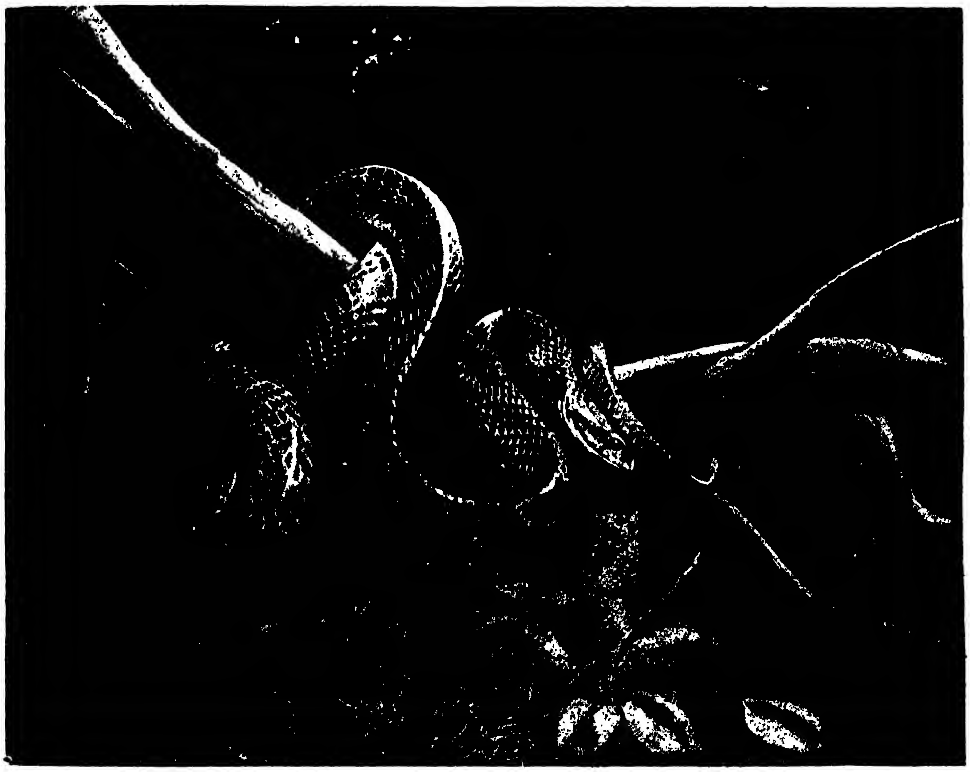
The cobra stands at the head of all the poison snakes in the popular mind, in which it represents the very embodiment of evil. We hear of it chiefly in India, but, of the ten species, only two are found in our Dependency. There is one in the Philippines, while Africa has the remaining seven species. The cobra haunts human habitations during the rainy season, and makes its way into roofs as easily as into sheds and wood-heaps. To understand the climbing powers of snakes, we had better glance more particularly at the mechanism of the reptile, for the climbs are achieved by the same means as the swift glide along the ground which carries the creature whithersoever it will.

Snakes have scores of pairs of ribs—some of them as many as three hundred or so—and each pair acts as a limb. The ribs, articulated together by means of a ball-and-socket joint, are attached at their inferior ends not to sternum, or breastbone, for the snake has not a vestige of one, but to a series of large scales upon the abdomen. By means of these scales, to each one of which a pair of ribs is joined, the snake is able to grip any inequality in the ground,

each pair of ribs pulling forward the scale to which the ribs are attached. The whole form one long foot. Some snakes, those especially that live chiefly in trees, have a decided keel which gives a further purchase and enables them to ascend any sort of trunk affording a grip.

Snakes cannot travel upon a perfectly smooth surface. Another thing which a snake cannot do is to move in vertical curves as old pictures represent. Like a twisted arrow it glides, but its undulations are always horizontal. Vestiges of the hind legs of the snake are to be found concealed beneath the skin, but the later method of progress seems quite satisfactory; and the man who finds a deadly serpent in the ceiling of his bungalow is quite satisfied with the climbing powers of the reptile. With an adult snake of the virulent type which is in full health, a mere scratch with the poison fangs may cause death, but with a real bite the death of a human being follows almost inevitably, within from half an hour to from two or three hours; lesser prey is killed almost immediately.

It is with the cobra, with his menacing, expanded hood, that the Hindus and Arabs exhibit their powers of "charming." The scene is familiar to the traveller, and its description to the reader. The secret of the "charming" is less well known. What really happens, before the show begins, is that the owner of the reptile, thrusting a piece of cloth near the mouth of the reptile, fastens its fangs in it, then breaks or pulls them out. This done, the poison sac is cut out or burnt to prevent it from being renewed. Fangs may grow again, and in all likelihood will, but once the poison sac is gone there can be no flow of venom into the mouth. But sometimes the imposture does not succeed. Cobras have been brought to the London "Zoo" and sold as tamed and harmless. Harmless they have indeed proved upon arrival, but when the "charmers" have departed the poison fangs have grown anew, and fatal experience has proved that the gland containing the venom has not been destroyed.



THE CORAIS SNAKE OF SOUTH AMERICA

How terribly poisonous is the cobra may be learned from an experience of Frank Buckland, who, seeing a rat killed by a cobra at the "Zoo," managed to have the dead rodent raked out to examine. There were two needle-like punctures on the skin;

and on scraping the latter away Buckland found that the flesh underlying seemed already affected with mortification, though the fatal wound was only a quarter of an hour old. While examining his prize, the naturalist became terribly ill, and had he not managed to get a timely draught of hartshorn he must have died. It proved that in cleaning his nails with a penknife earlier in the day he had slightly separated the skin from the nail; and when he came to examine the rat some of the virus from its body worked into the wound and acted as described.

There is a more formidable cobra than the one which we have been considering, and that is the king-cobra, or hamadryad, which lives mainly upon other snakes, poisonous or non-poisonous, and feasts with as little ceremony upon another cobra as upon an innocent constrictor. The king-cobra is more to be feared than most poisonous snakes, for this one will attack a man with less provocation than the rest, which will avoid combat when possible, striking only when attacked or believing themselves in danger. The king-cobra does not wait for the danger to come to it, but strives to get its blow in first.

Colonel W. A. Michell describes a desperate adventure with one in the valley of the River Surjoo. He was riding a pony only $12\frac{1}{2}$ hands in height, when suddenly he came upon a king-cobra. The latter, as the pony drew up to him, devoted his attention not to the animal but to the man. Expanding its enormous hood, it struck viciously at the rider's foot, but met only the thick, nail-studded sole, which was afterwards found coated with poison fluid. Colonel Michell had left his gun with a native who was following up on foot, but when the man, hearing cries for the gun, hurried up and saw what was toward, he fled. Meanwhile, the Englishman, who had in his hand only a slight switch which he had cut to keep the flies off his mount, was attacked four times by the cobra, but on each occasion managed to oppose his boot to the reptile's onslaught, and to beat it about the head with his switch. At last the snake became coiled about one of the pony's legs, and was trodden upon. Still it did not turn to bite the horse, but reserved itself for the rider .

"Finally, I flicked the king-cobra once more over the eyes, and at the same time, bending over the pony's head, and leaning towards the reptile, I gave a mighty, thundering shout. This was too much for my opponent, which was terrified at last. He now backed off the road, disappearing into the high grass and brushwood bordering the path," where the colonel eventually had the satisfaction of giving him a lethal dose of shot from his recovered gun.

The colubrine snakes, the largest of all the groups, serve to enforce the lesson that snakes nearly allied may differ as to their harmfulness. In this family, which comprises no fewer than forty genera, we have three distinct groupings. There are first the

MALE AND FEMALE OF SHORT DEATH-ADDER OUTSIDE THEIR LAIR


THE BLACK COBRA


THE SPECTACLED COBRA


THE RING-COBRA

solid-toothed colubrines. These are the most primitive of the series. They have not developed the poison duct and hollow fang, so can do nothing worse than inflict an ordinary bite. The second group, called the hind-fanged colubrines, have only one or more of the hind teeth grooved, so that, while some may be harmful without being fatal in their attack, others are quite innocuous. The third series includes the front-fanged colubrines, all of which have the front teeth of the upper jaw either grooved or tubular for the discharge of the poison of the typical venomous serpent. A couple of English snakes belong to the first series of this family—the ringed snake, which is an expert swimmer, and takes fish, as well as frogs, mice, etc.; and the smooth snake, both being quite harmless. The last-mentioned, however, is a pugnacious member of the family, and by those who dislike serpents will be none the less esteemed on this account, seeing that it eats other snakes.

Another of the group which we might welcome, if we could dismiss it at pleasure, is the rat-snake, non-poisonous, but a deadly enemy of rodents. This genus, under many different names, is represented in Europe, Asia, and Africa by a score of species. The Æsculapian snake, typical of another large genus, extending from the Old World to the New, is a friend to the agriculturist, in that it subsists mainly upon field-mice, and poisons not, though it bites the hand stretched out to take it. The four-lined snake is another aid to European field-culture, for to mice and rats it adds moles and lizards, and helps to keep down excessive numbers of birds. A similar testimonial may be given the black-marked snake, which pursues mice into their holes and birds into the trees. This snake is remarkable for the keenness of its vision, a faculty in which snakes might scarcely seem to be specially endowed, for their eyes are immovable, and are covered by a transparent horny cover, likened to the glass which protects the face of a watch. This sheath is cast when the skin is sloughed, an operation performed three or four or more times every year.

Some of the foregoing genera are called water-snakes without being exclusively aquatic, and now we come to the wood-snakes, which are purely arboreal, the tree-snakes of the Old World and Australia, similar in habit, and the nocturnal tree-snakes of the Old World, but not Europe, and sufficiently described by their title, albeit some are purely terrestrial. Sandwiched between these groups, however, we have an extremely interesting snake (Dasypeltis scabra), which subsists almost entirely upon eggs. Here we find a very remarkable adaptation. In both jaws the teeth are rudimentary, and absent from the front, to admit of the reptile's safely taking an egg into its mouth. Its teeth are in its gullet, far down. The lower spines of the vertebræ penetrate the œsophagus and serve to crush the shell of the egg as it passes towards the reptile's stomach. Other snakes take eggs, but the little egg-snake could not safely rely upon such a diet if the egg were crushed in his small mouth; the fluid of the egg would escape. When the egg

passes his throat, he obtains 100 per cent. of nutriment from it, and so justifies his unique dentition.

Passing now to the third series of the colubrines, we reach such deadly reptiles as the cat-snakes, the masked adders, the kraits, and the long-glanded snakes, which latter, not content with confining the poison bags to the upper part of the back of the head, have them extended along each side of the body, so that the entire internal organism of the reptile is modified, the heart having been forced farther back in the body than in that of any other snake. It is fortunate that this peculiarity has not been emulated by the kraits, another of our Indian scourges, for these snakes are, next to the cobra, the most deadly in the land, and kill more people than all the rest of the snakes put together—the cobra excepted, of course. The banded krait, or king-snake, which is known to attain a length of six feet, is popularly considered the most terrible, but experiment has shown that the common krait is actually the more deadly. The latter is a superb climber, and leaps with death in its fangs from all parts of an Indian dwelling. Possibly none of the kraits is as potent as the death-adder of Australia: but, though this latter is held in mortal detestation by natives and Europeans alike, relatively few deaths are caused by it, owing to the sparse population in the areas where this reptile roams.

A BULL-SNAKE AND ITS EGGS

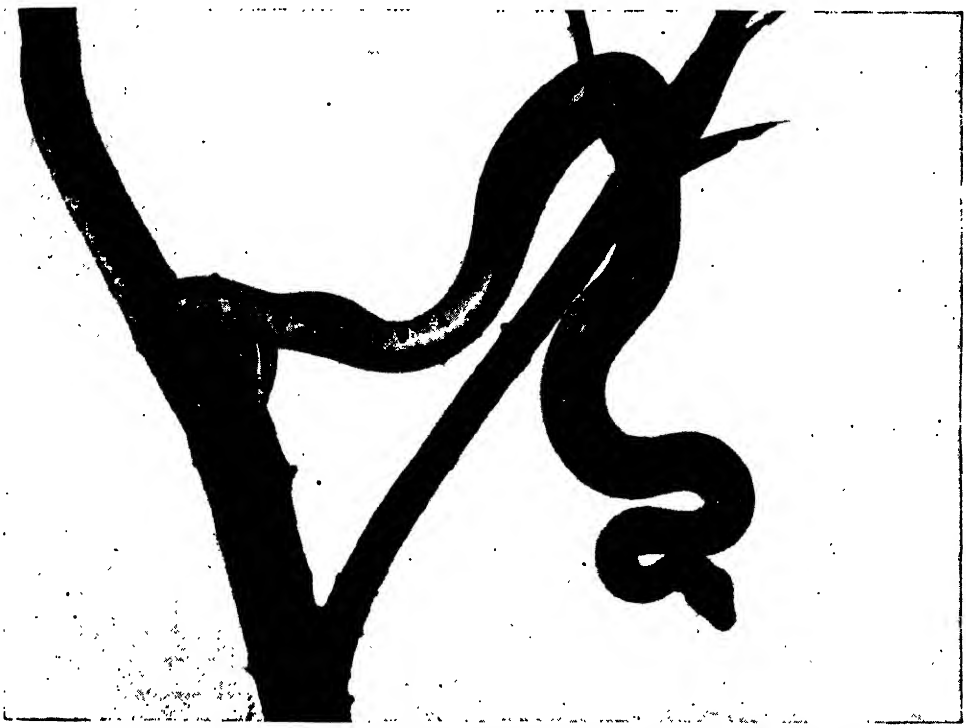
As has been noted, the sea-snakes, to which we next come, are really the most poisonous of all. They are not to be relegated to a separate family, for investigations go to prove that they began where the rest of the colubrines began, and have increased in virulence with the needs of the life which they pass in the sea. There are four genera of them, and so thoroughly have they adapted themselves to life in the sea and tidal waters that only one, the broad-tailed sea-snake, ever quits the water except by accident. Needless to say, the sea-snakes breathe atmospheric air by means of lungs in no respect different from those of terrestrial snakes. Their existence is, of course, no support of the foolish tales brought forth every summer by inexperienced visitors to the seaside as to the "sea-serpent." The difference between a sea-snake and a sea-serpent is this: that the sea-snake is excessively abundant in actual life in the warm waters of the Indian Ocean, in the tropical Western Pacific reaching from the Persian Gulf to New Guinea, Northern Australia, and from the western coast of Africa to the western shores of tropical America, and away to New Zealand, Manchuria, and Japan; while the sea-serpent is a myth swimming within the ken only of the imaginative, who are incapable of recognising darting sea-birds in a line, or a school of porpoises in column, or the fins of sharks or whales, or even an unwontedly elongated variety of ribbon-fish. That is the only distinction, but perhaps it will suffice.

Coming to the viperine family, we reach one of the deadliest assemblages of snakes. All are poisonous, even the least noxious, the common or British viper. This, which should never be handled, is not so readily distinguishable from other snakes as could be desired, owing to excessive variability of marking, but one will be on the safe side always to avoid a snake which has a zigzag pattern running down the back, with an inverted capital V on the head. The average length of the British species is eighteen to twenty-four inches, so that the poor slow-worm, which is shorter and quite different in marking, should escape. There are a dozen genera of vipers; and the mere names of some of them, such as Russell's viper, the puff adders, the various horned vipers, the rat-tailed viper, and the rattle-

snakes, suffice to inspire a sense of discomfort in anyone familiar with the habits of the reptiles themselves. The largest European representative of the group is the long-nosed or sand-viper. Russell's is one of the plagues of India, deadly to cattle, and responsible, no doubt, for many of the 90,000 included in the annual "kill" by wild animals. The puff adder is the most terrifying in appearance of all the poisonous snakes. It inhabits sandy wastes, and upon being disturbed raises its hideous, triangular-shaped head, and draws in a deep breath, which it respires with a hissing, puffing sound; and woe betide the living thing within reach, be it horse, camel, or man.

Perhaps the horned viper is even more dreaded than the puff adder, for this malignant foe of all forms of life coils itself up on caravan routes, in the depressions caused by the feet of pack animals, leaving only its head exposed, to dart with a unique sidelong action, and inflict its fatal bite, from which a healthy man will die in half an hour. It is believed that Cleopatra's asp was a horned viper, possibly Cerastes vipera.

As the king-cobra, measuring nearly fifteen feet in length, is the largest of all poisonous snakes, the rattlesnake is, with the exception of the bushmaster, the largest of all the vipers. The length of the female diamond rattlesnake—the "weaker vessel" being the larger—is sometimes over eight feet. Pit-vipers—so called from a deep depression upon the upper part of the head, of unknown purpose—range throughout Asia and America, but the rattlesnake is peculiar to the New World. This viper is notable for the singular rings of hollow, quill-like horn at the end of the tail, interlocked one with another, yet so elastic as to permit considerable vibration, resulting in the "rattle" from which the reptile derives its title. Naturalists do not agree as to the purpose of this rattle. The old idea that it is a merciful provision of Nature to warn the victim of its impending doom is, of course, nonsensical; that is not Nature's way. That it is intended to frighten off hostile birds or animals seems more possible, but as the bark of a dog would but call a puma to feast upon the dog, so the rattle of the snake would summon pig or other predatory animal or



THE BOA-CONSTRICTOR IN THE ACT OF LAUNCHING ITSELF FROM A TREE

bird to banquet on snake. There may be something in the suggestion that the rattle, whatever may have been its origin, serves as a means of communication, for whenever one rattlesnake shakes his "quills," every other rattler within hearing will respond in like fashion.

Reptiles, as a rule, display but slight regard for their kind, unless possibilities of snake eating snake be toward, but the rattlesnake is famous for its winter parties. It is clearly established that in the colder latitudes these reptiles, where they still survive in large numbers, make quite considerable journeys in order to spend the winter in company, twisted and entwined "like a huge mat wound and interlocked together, with all their heads, like scores of hydras, standing up from the mass." So the picture is described by one who in his youth saw between 500 and 600 of these reptiles killed at a single cave.

With the advance of man into the wilds, rattlesnakes are slowly vanishing. Man and his pig are accounting for these, the deadliest reptiles on the American continent. Man has his gun and his hatchet; the pig has his appetite and immunity to snake-bite. An Irish peasant, who keeps his pig in his parlour, would be serenely happy and secure in rattlesnake land.


KING-SNAKES EMERGING FROM THE EGGS

Turning to the pythons and boas, we reach a group of snakes whose dimensions render credible the evidence of the rocks as to the size of the serpents of old time. The average work on natural history hardly gives us a true notion of the size of these reptiles. The naturalist seeks to preserve an impartial balance between his own sceptical attitude towards measurements of animals with the largest types of which he is never brought face to face, and the figures enthusiastically inscribed upon the diary of the traveller. Hence we have the medium, average size of the monster snakes represented on the one hand as the maximum, and on the other hand the hunter's exceptional trophy represented as though it were the average.

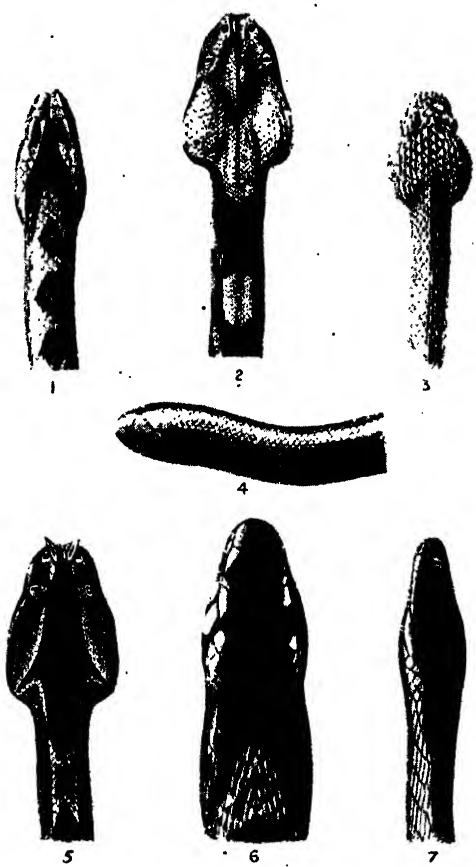
The pythons and boas together form one family of some twenty genera, the whole being grouped as the Boidæ. Of the pythons we have some half-score species, distributed over tropical and South Africa, south-eastern Asia, and Australasia. These are the largest of all snakes with the exception of the anaconda. So long as a snake at large is healthy and active enough to continue to feed and frequently to cast its skin, there seems no reason why it should not, in favourable circumstances, continue to grow, as a crocodile grows. Even the Malayan python, long regarded as among the smaller of the brigade, is now found to exceed thirty feet in length. The average is fixed at from half to two-thirds of that length. Expert swimmers, the pythons are largely arboreal, but the bulk of their prey is caught upon the ground, where small deer, half-grown sheep, and larger animals are seized, crushed, and consumed. The method of taking their prey is the same in all the species. The animal is firmly gripped with the back-curving teeth, which make it impossible for the victim to escape. Then the mighty coils are flung round about the body, which is crushed by a crescendo of pressure, until it assumes a sausage-shaped mass.

As the viper rears its head and seeks to bite the moment it is liberated from the egg, so the young python almost from birth shows the ability to crush and smother. At any rate, pythons, incubated in private, when ten days old flung themselves round the bodies of sparrows and crushed them in a way that would have had the approval of the mightiest adult specimen. Capacity of swallow varies in the python with the size of the reptile, but we must not take it that the Zoo python which died from an injury to its jaw, fractured from swallowing a goat in 1911, is typical. The free snake is infinitely more lively and powerful than the cribbed, cabin'd, and confined example with which our private collections make us familiar. The jaws are the same in captive snakes and free, of course, but in a state of nature the reptile is in constant training, so

to speak, not fasting for such prodigious periods as in the case of captivity. The manner in which large kills are swallowed is this. The lower jaw, as we have seen, is elastic, the bones being separate, and held together by a powerful, pliable ligament. Where the brute grips, there it holds, but, in order to swallow, it has practically to draw itself on to the body, as a glove upon the hand. This is effected by the lower halves of the jaw practically walking forward alternately, a fresh inward pulling grip being secured at each step, while mucus is freely discharged upon that portion of the body lying within the mouth, so lubricating it in its progress down the throat.

Whether a large python or boa will eat a man or not is disputed. There is presumptive evidence against the reptile, from the fact that if it once bites it must swallow, or die in the attempt. One at the Zoo ate a blanket, which it accidentally caught in its teeth. In 1849, a python at the Zoo, measuring nine feet, swallowed another python only a foot less in size. A similar thing happened eighteen years ago, when a python of eleven feet, snapping at a pigeon which was in the jaws of another python of rather more than nine feet, caught the head of the latter and was compelled to swallow the snake at the end of the pigeon. This it did during the night, and the keeper in the morning found two snakes in one, the outer specimen bulging at every scale. The first case was, however, the more remarkable, for the victim there had doubled up in the gullet of his destroyer, and had extended him to treble his normal girth for about a yard beyond the head.

The anaconda, monarch of the boas, is commonly credited with a length of from thirty to forty feet, and girth proportionate, and certain naturalists sniff uncompromisingly at stories of forty feet of anconda, although Bates records one of that length which seized a boy by a riverside. But although we may ask for better evidence upon the point than Mr. Algot Lange's "anconda skin measuring 54ft. 1in. in length and 5ft. 8in. in width," for we know how these skins stretch, yet there is no challenging the careful statement laid by Major P. H. Fawcett before the Royal Geographical Society in 1910. In an unadorned narrative he told of killing one 65 feet in length, while another party reported to him one of 85 feet. The second may stand as a statement "not proven," but Major Fawcett's measurements must inevitably find a place in our natural histories if the editors of these latter keep abreast of unchallenged data.



THE CHIEF POISON-SNAKES OF AFRICA

1, Causus rhombeatus; 2, Bitis gabonica or Gabun puff-adder; 3, Atheris chlorechis; 4, Atractaspis irregularis; 5, Bitis nasicornis, the nose-horned viper of West Africa; 6, Naia melanoleuca, a cobra; 7, Dendraspis viridis.

The anaconda is python-like in habits, living a great part of its time in the water, and climbing trees with the ease and certainty of some mighty vine endowed with animal life and powers of free locomotion. Snake life reaches its zenith in the anaconda; and South America, of which it is a native, is exactly the place in which we should expect to find it, that land of strange, uncanny giants, of which this reptile is at present the only known surviving relic. If giant sloths and contemporary Titans are extinct the anaconda remains, an equal marvel.

ABSORBING INTEREST AND CONCENTRATION THE SECRETS OF AN INDELIBLE MEMORY

YOUNG WALTER RALEIGH LISTENING ENTHRALLED TO A MARINER'S STORY OF THE NEW WORLD WHICH IN LATER YEARS HE HELPED TO EXPLORE

From the painting by Sir John Everett Millais, P.R.A. at the National Gallery of British Art.

MEMORY AND ATTENTION

How We Retain Interesting Experiences, Recollect Them, and Recognise Them when They are Recalled

THE ART AND SECRET OF LEARNING

Having studied the facts of sensation, and the way in which we associate the impressions which we have derived from sensation, we have already had plenty of occasion to observe the vital property called memory. Only a few points need reference before we pass on to more difficult matters.

First, we have seen that, in the philosophical sense, all living things remember, and they alone remember. We are thus the sum and issue of all our past. Probably nothing is forgotten—somewhere. Once and for all, we sharply distinguish between the primary fact of memory, which is *retention*, and the secondary fact, depending on the first, which we call *recollection*. We all know quite well that, when we say we "can't remember," we mean that we cannot recall what, in fact, we know to be remembered somewhere within us. We say, "It will come back to me in a minute, though it has slipped my memory just now." Obviously, common speech here, as usually, confounds two distinct things, and on consideration we see that the process of retention and the process of recollection are quite distinct. Each of these two processes requires some comment, but first we must observe that there is a third process involved in memory, which we call recognition. We may retain, and recall, and then not recognise the memory in question. We may fail to recognise what, in fact, we remember, such as the face of someone who greets us with the infuriating observation, "I'm sure you don't remember me." There the word "remember" covers more meanings than one. In point of fact you do remember the face, in the sense that it has been retained in memory, for you know that you have seen the man somewhere before. But for the life of you you cannot remember where. In a word, the act of memory which we call recognition has failed. But if he follows up his ingratiating introduction by a series of hints—"Last summer," "The best of afternoon parties," "A cricket match"—at any moment the act of recognition may follow. Now let us note these three constituents of memory in their natural order.

Retention, the primary fact, is natural to all life, as we have seen, but its intensity varies. The degree of retentiveness is probably a native characteristic of the individual, and is to be treated as such. Disease or intoxication or senility or shock may diminish or destroy it. It varies in the course of the individual life. During some years before puberty, sheer retention is often extraordinarily accurate and easy. The child remembers names, poetry, and so forth with incredible ease. Shortly this acuity diminishes markedly, and few adults can remember as they did in their teens, if by remembering we mean merely retention. In senility the decadence of the power to retain is very marked. The memory of the remote past remains, because the retentions were made by younger nervous tissue, but new retentions are made with difficulty, so that recent facts are not remembered, though remote ones, which we might think more difficult to remember, are accurately retained and reproduced. The explanation of this paradox is now apparent.

The most important fact about mere retention-memory, after its universal character, and its indispensableness for all the higher operations and possibilities of the mind, doubtless is that, so far as we can discover, it is what it is, and will be what it will be, except that it can be damaged. It cannot be improved or educated. Education of the right kind will do marvellous things for the memory, but

not for this part of the memory. It follows that all "learning by heart"—"To know by heart is not to know," say the wise French—and all schemes and education which assume the value of such rote-learning, must be condemned. Certainly it is necessary to retain, and if these methods increased the power of retention they would be valuable, however worthless the subject-matter, however tiresome the process. The psychological condemnation of these methods depends upon the fact that they do nothing for the memory; or, rather, they do nothing for retention-memory, while they neglect and often injure the higher parts of the memory, which can be educated.

Value in the Subject Matter the Only Excuse for Learning by Rote

For all learning by rote, then, two warrants henceforth can alone be admitted. One is that this is a discipline. On that we need say no more than to deplore the existence of those who have no higher and deeper ideas of discipline than the enforcement of what is wearisome, for no worthy end. The second is that the subject-matter of what is taught may have value in itself. Thus, it neither improves the memory nor the reason to learn that "through" and "though" and "trough" are pronounced as they are, but it is useful. What one requires thus to remember, as distinguished from what should properly stay in reference books, until the man who has a really educated memory finds his sure way to it, may therefore be taught by rote and repetition; and even what was not appreciated at the time, like poetry, may be gratefully remembered afterwards. But this purely mechanical method of schooling is not to be called education, must be sharply limited in its employment, and those who employ it beyond those limits must be looked upon as either ignorant of elementary psychology, which is their business, or as too idle to teach honestly.

The Impossibility of Finding Anything in the Brain that Corresponds to Memories

It need hardly be said that to teach by rote requires no qualities on the part of the teacher, and is therefore the natural resort of the idle and incompetent, who may thus readily be identified, where the teacher has any choice at all. Of course, no reference is here made to those who teach as they must, thanks to the demands of red-tape and examinations.

What fact, in terms of nerve cell and fibre, corresponds to retention, no man can say. No doubt there is some physical fact which corresponds to the psychical fact, but when the physiologist and the microscopist are challenged as to the physical basis of memory they have no answer. The brain of any one of us is somehow the storehouse of a vast variety of memories, of words, experiences, people, things, which were not there once. No one could make sections of such a brain and point to the appearances, under the microscope, which correspond to these memories, and which would not have been there ten or twenty years before.

No observation has distinguished between the speech centre of a linguist and that of a peasant whose vocabulary only contains three hundred words, or between the music centre of a great conductor, who can conduct fifty operas and symphonies without the score, and that of a man who only knows bits of a few tunes, and knows those wrong. Yet, whatever our theory of mind and body, whether we follow Haeckel or Bergson, Lucretius or Plato, we are all agreed that there must be some material difference in the brain which stores memories, as compared with that same brain before they were stored.

The Marvellous Book of the Brain Kept in Invisible Type

The sheer amount of what the brain can retain is staggering. A great linguist or philologist, a great man of science, expert in some department, but with a vision of the whole, a monarch like the late King Edward—such people have brains the memory contents of which could not be written out in years, and which could not be printed, in any visible type, except in a number of volumes which would many times outweigh the whole brain in question, and many times more the grey matter, which alone remembers. If things be "printed" on the brain, the type is ultra-microscopic. We have said we know nothing as to the material basis of memory, but at least we know that the nerve-fibres do not remember, can have no more memory than telephone wires of the conversations they transmit. They can be severed and utterly degenerate, and then be replaced by new fibres, without the slightest impairment of memory. We are therefore certain that it is the nerve-cells which remember, and we can say no more.

The total weight of the grey matter of the brain, apart from the blood in it, is a matter of a few grains. True, there are many millions of cells, and when our minds

are utterly baffled by the fact of memory, they must try to get what reasonable satisfaction they can out of this huge number. Many cells may be involved, must be involved, in what, for us, is one memory; and each memory of the millions which our brains soon come to contain may correspond to a special combination of an unknown number of cells. But all this is speculation; the fact is that we know nothing, and the more we learn the more we feel forced to the old view, long scoffed at, and now returning, of the psychical entity, the soul, which indeed is the seat of memory, and which, in some inconceivable fashion, employs various portions and combinations of the organ we call the brain.

The Physical Condition of the Brain Vital for Memory

If, on the other hand, we feel inclined to rest in this conclusion, and to let the study of the brain "slide," we must learn how vital for memory is the physical condition of the brain. A mere rough shaking of the brain, producing what is called concussion, may completely obliterate memory; the condition produced by asphyxia, as in drowning, may revive memories thought to be long lost; various intoxications will ruin memory; and in all these cases we can only say that some physical change has been wrought, but of its nature no one knows anything.

The second function of memory, which we have called recollection, and the third function, which is the recognition of what is recollected, can be defined in terms of association, as we are already aware, and as is indicated in the process by which a half-remembered stranger restores himself to our recollection. He rouses one association after another until recognition is thereby attained. But the supremely important fact about these two functions of memory is their entire oppositeness to the primary retention in respect of educability. These can be educated, by association, by making many and relevant associations; and therefore, while education is impossible and only disastrous in respect of what rote-learning is designed for, real education is invaluable for its services to these higher functions of memory.

The Wonders of Associative Memory in Clever Men

There is no mistaking the brain, originally of high quality, in which the associative memory has been properly trained. Its freedom depends upon its chains. In speech or in writing, the possessor of such a memory shows himself at once. It is not necessarily that he remembers names, dates, numbers, like some of the extraordinary persons occasionally seen in music-halls, in whom the retention-memory is developed beyond all belief, but who may be nearly imbecile in all essentials. The people of whom we speak may have retention-memories of any class. Their strength is in the chains of association. The mind travels, "quick as thought," "from grave to gay, from lively to severe." The apt illustration, the right quotation—which may or may not be verbally accurate but retains its point, by which it was then and there remembered—the just marshalling of relevant facts, all these are essentially feats of memory.

In time past, retention-memory had its uses, because tradition was the only means of preserving knowledge and achievement. The old man who could retain what he had been taught, and pass it on to his juniors, selected for their native capacity, was necessary for the maintenance and advance of primitive civilisation. Today the arts of writing and printing serve the purposes of retention-memory in perfection, and to regard education as the development of this kind of memory, even if that were possible, is to place man lower than his own inventions.

The Right and Wrong Methods of Utilising the Memory

The object of education is no longer to make a man into a "walking encyclopædia," but (among other things) to make him capable of using an encyclopædia. The great workers and students and thinkers deliberately refrain from the attempt to memorise things. They value their brains and their time far too highly. What lesser people strive to retain for use, these merely know where to find; and the knowledge does not fail them at the right moment, in speech or thought, though the others, who have it all in their heads, may never be able to use it.

This contrast, upon which we cannot too earnestly insist, is never better seen than in the methods of different students, following lecture or book. One will boast that he has got down every word, and will then try to memorise the whole. If he is questioned suitably, he can reproduce it all, at examination, like the guide at a show place. If he be asked another question, which requires the associative use of this piece of knowledge, it simply fails him. He has the wrong kind of memory. His is the memory of a talking-machine; he is making himself

into a gramophone instead of a man, which appears to be the aim of most of our present education. The other student merely listened to the lecture, perhaps with a jotting or two; he may have "read" the book in three hours, where his fellow spent three weeks. But he has got hold of the chains, he knows the ropes, and he will pull them when required. That book and its contents are his henceforth, though he owns no copy, and may not refer to it again for a decade. When the need arises, his mind will tell him that he must look up a certain chapter, or will even save him so much trouble as that. And, of course, the man's processes seem magical to the gramophone, poor fellow.

The Misdirected Labour of Trying to Improve Retention Instead of Association

"He who has learnt how to learn can learn anything," said Carlyle, who was a great learner, and knew. We see at once what he means. And the reason why this analysis of memory is so necessary, and is being reinforced here with every kind of illustration, is that, in ignorance of psychology, the world of education is full of misdirected labour. National education and self-education, the work in our medical schools and everywhere else, is vitiated right and left by the lack of a clear understanding of the facts of that which we are trying to educate. After leaving school, most of us realise that the time has come for our education to begin, and we look about us for methods and for advice. People are to be found who undertake to improve our memory for the purposes of learning, and we go to their lectures or read their books. But we must distinguish between them, for ourselves, on the basis of the psychological analysis which is here made.

If they try to improve retention, let us have no more to do with them. It cannot be done, nor is it worth doing, except for the purposes of examination by imbeciles in high places. If they try to stamp things into the mind by any process of repetition, however disguised, then we may know that they have not got the root of the matter in them.

The Indelible Engravings Made by Associative Memory Without Repetitions

The one mechanical fact, so to say, that we know about the elementary, universal fact of retention-memory in living things is that it largely depends on repetition. You hear your own name and write it so often that you are not likely to forget it—"I know it as well as my own name." So with languages or anything else. But associative memory is essentially independent of repetition. In very many instances the association, once made, and never repeated, is there permanently. Most of us have such associations which we would gladly be rid of, but we never will. The event was never repeated, but the association is engraved indelibly in the memory, and that name, that tune, that odour, that place, will recall something else to the end of our days. Everyone who has had a great teacher can recall the place where he stood and heard his master say some memorable thing, and the name and the place and the saying are associated for ever, though never before or since were those words said. Contrast this case with the task of getting up a list of dates, and the only method which will there avail.

Alike for retention, recollection, and recognition, there is a factor to which we have not yet referred, but which is of overwhelming importance. We may call it interest, or we may call it attention, and it is both. If we are interested, we attend; and if we attend, and largely in proportion as we attend, we remember. If our interest be intense, our attention is intense, and the memory will be more durable. The literal meaning of the word "interest" is the key to this fundamental fact of psychology. The Latin verb "inter esse" means to "be among."

Vital Interest the Master-Secret of True Memory

Interest is a vital state of relation to something which *vitally* concerns us, so that *we* are among and within it. Everyone is interested when a motor-car threatens to run over him, when his house is on fire or rocks with an earthquake; and we are apt to remember these occasions. The deepest nature of a human being is thus exposed in his interests and memories. The selfish man is interested in and remembers only what concerns him—"A pimple on his nose interests him more than a cancer in his neighbour's mouth," as the writer once heard one of his teachers say. Most of us are more interested in, and will better remember, a scandal next door (which was not true, any way) than an epidemic or tidal wave or famine that has destroyed millions in China, though we read about it, with languid interest, every day for weeks. Not magnitude, not repetition, but interest dominates; and what shall interest, what we shall feel that we "*are among*," depends

on what we ourselves are. It depends on our deepest nature and our experience. You have never been to Copenhagen, and news therefrom scarcely moves you; or you once spent a long holiday there, and everything you can see about it interests you. This is clearly a case of interest aroused by association and ultimately depending on interest in the literal sense again; it is *your* Copenhagen, *you* were once there. We all know selfish or small-minded people who, in conversation, respond or revert to only those things which interest them, because they have been to the place, they know the author, their aristocratic friend has seen the play, and so forth.

Everyone can distinguish, in conversation, the man who is interested in himself, and the man who is interested in *us*. What associations does his tongue run to!

The Will to Live Roused Spontaneously by that which Fascinates Us

Nothing could be more obvious, more important, more elementary, than this principle. Yet, clear, cogent, universal though the principle be, the greater part of all education flouts it, ignores it, seems deliberately calculated to insult it. We want the boy, the girl, the student, ourselves, to remember; then we must arouse interest. Somehow, their "will to live," their *élan vital*, as Bergson calls it, the thrust of their lives, must be engaged along this line. We may succeed, honestly or dishonestly. The child may care nothing for the subject, but much for the prize. We get his interest, and he learns: more shame to all concerned. No child in Japan can work for prizes, for there are no prizes.

Or we are interested because the subject simply fascinates us, and so we learn; or the personality of the teacher or his way of writing is irresistible, and we read what we would never have expected to find ourselves reading. Some strength, kindliness, knowledge, humour, passion, in the author interests us, because these vital qualities serve our lives, thus interesting the deepest thing in us, which is the will to live; and we listen.

Concentration by Shutting Out the Things that do not Interest Us

We may have heard the same thing a hundred times before, but we have forgotten it; now we remember.

We forgot because interest was not aroused, attention was not secured; the deepest *we* of us was not really there at the time. Compare half a dozen people, in one house, reading the same paper, and all this is illustrated. They all glance down all the columns. One could never tell you that there was anything about cricket, or about tuberculosis, or about the weather; another saw nothing else. The eye at once forgets what it did not want to see.

But we must leave this primary fact, with all it means for teaching and learning, and therefore for all of us; and we must examine the exact mechanism by which interest works out in attention, and thence in memory. Here we are all indebted to Professor Sherrington, of Manchester, who has devoted many years to the physiology of attention in terms of reflex action. His study shows how, despite the incredible complexity of the nervous system, we are able to attend, to be single and devoted, to one thing at a time, to the exclusion of others. It is then, when we are in "rapt attention," based upon vital interest, bodily or mental, that we remember.

Even in a very simple nervous system, and far more in ours, any one sensory nerve may carry impulses that run out, so to say, along any of many motor nerves. Thus, unless some guiding principle be at work, all impulses, coming through eye, ear, skin, and so forth, will issue in acts of attention or of motion, all helter-skelter and perhaps contradictory.

The Inhibitory Action of the Nervous System Giving Precedence to Our Main Interest

But Professor Sherrington has found, in all the types of nervous system that he has examined, and not least in man's, the existence of what he calls a *common path*, along which sensory impulses must travel before they produce results. And the point is that this common path is like the trunk line of a telephone. A subscriber in Eastbourne is talking to Bradford. Meanwhile, other people who want to talk to Bradford from the South of England must wait. The first subscriber occupies the common path, and blocks the line for all the others. This is exactly what Professor Sherrington has proved to be true of reflexes in general. They inhibit one another, fortunately for us. If one sensory or ingoing impulse gains possession of the common path, the others must wait. If the subscriber in Eastbourne shouts fourteen, and another in Bournemouth shouts four, the subscriber at Bradford hears neither eighteen, the sum of the two figures, nor ten, their difference. He hears fourteen or four, one or the other. Thus for him the complex telephone system is quite simple, a single wire from Eastbourne to London, and

another from London to him. And Eastbourne is fortunate to have secured his attention by getting command of the common path, and blocking it for everyone else. " Gooseberry " trying to get a reply from one of a pair of lovers knows what this command of the common path, to the exclusion of all other impulses, means.

A beautiful illustration from Professor Sherrington shows this vital unity, in practical working, of the nervous system, and the fashion in which what dominates by its interest monopolises attention, and so makes its impression upon memory.

The Brain's Impulse to Deal with One Thing at a Time

Suppose two objects simultaneously presented to the eye, but seen not by the centre of the retina, but by what children call the " eye-corner." Either of these objects alone would excite exactly such a reflex action as would swing the eye round so that the light from the object in question would impinge upon the " yellow spot," the most sensitive part of the retina. What, then, happens when two objects simultaneously attempt to gain the individual attention of the eye ? If they lie to the right of the field of vision, and in a horizontal line, will the two stimuli be *summated*, as physiologists say, so that the eye swings round nearly twice as far as it should, and thus obtains a good view of neither object ? Or will the eye respond to the difference between the two stimuli, with the result that it swings round too far for the clearest vision of the one object and not far enough for the clearest vision of the other ? Neither of these undesirable events happens. One impulse or the other gains complete control of the common path, to the entire exclusion of its rival, and the eye is fixed upon either one object or the other. Whichever has most interest in it gains the attention, and the other is as if it were not there. Try to teach a class of children the exports of Brazil when a fire-engine is dashing past the window !

The Theory that Attention is an Act of the Will

We cannot explain attention except with such help as Professor Sherrington affords us, and with some reference to the will. The fact that attention is related to will, subconscious or conscious, is evident to anyone who remembers an occasion when his attention began to wander and was forcibly recalled, as when you are talking to, or being talked to by, a dull person, and find yourself listening to someone else, who is interesting. Professor Wundt, the great German psychologist, has argued that attention is essentially an act of will ; and if our view of will is deep enough, and includes the " will to live," which animates the whole of our behaviour, we may agree with him. At any rate, the telephone analogy holds good ; and the idea of the " trunk line " illuminates the problem of attention, and the fact of our amazing unity of interest, attention, response, and memory, notwithstanding the variety of things that pour in upon us, and the measureless multiplicity of our nervous possibilities of attention and response. When we attend to a voice or a sight, to the exclusion of other things, what is it but the complete possession of the " common path " by the sensory impulses excited by the object in question ? In consequence of their control of the common path, these impulses are able to command all the muscles which subserve attention. For it must be remembered that there is a very definite motor or muscular factor in attention ; and so much the more do we see it to be a positive act of will, and not something of which we are the passive object.

The Absorption Possible when a Dominating Influence Commands the Nerve Tracts

For instance, you are enthralled by a great singer at the end of an opera. In vain part of you says to part of yourself, " You'll be late for your train," nor are you aware of the fact that the man next you is standing on your feet as well as his own. The singer has exclusive use of the common path. And what is the motor aspect of this state of strained attention, as we significantly call it ? You cannot cock your ears forward, though the muscles are there and you would use them if you could. But the *tensores tympani* are tightening the drums of your ears, so that they may respond to aerial vibrations with as little loss as possible. Many muscles of the trunk are in contraction, so that your body may be rigid and make no sound. " The audience was held breathless," we say : so eager are you that you even hold your breath. The singer has gained such exclusive possession of the common path that even the reflex action of breathing is interfered with, for a time. Your eyes are fixed, your pupils dilated, and, in extreme cases, muscular tissue behind the eyeballs is excited and pushes them forwards, lest they miss anything. Perhaps the sensory nerves of the spine are also excited, so that you feel " cold shivers down your back,"

while the secretory nerves of your lachrymal glands may be violently stimulated.

Thus complex is the combination of reflex actions which constitute the act of attention in this instance, though the exciting impulse is only single (if you cannot see the stage), or at most double, if you can see and hear. The dominant interest, proceeding from the stage, has gained the common path; all other things cease to exist for the time, are neither noticed then, nor likely to be remembered afterwards. This interest, acting through the common path, ramifies in many different directions, affecting motion, secretion, sensation, through as many different nerves, but all harmoniously and to the one end, expressive of the one interest. These are the occasions we are likely to remember.

Interest, Attention, and Memory the Highway of Learning

Interest, attention, memory is the sequence, and here the teacher and the learner must follow the indications of psychology. In such a case as we have quoted, the beauty of the sound, the personality of the singer, the "human interest" of the story, suffice to gain the attention, and the rest follows. But in a thousand everyday cases interest cannot be aroused at first, and the teacher despairs of getting results. How is he to succeed? The first recourse may be had to the old method of repetition. Even without interest, sheer repetition, acting in some mechanical way, may do something. If the class will not be interested, and learn in that way, it must go over the thing time and again, and learn in that way. But the wiser teacher makes a better choice between the two alternatives which are offered him. The one is repetition, failing interest. The other is to arouse interest, and then all will be well, with little need of repetition, no drudgery, and permanent results.

Heartbreaking Dullness Enlivened by the Magic of Association

But how arouse interest, where none exists, in a subject which must be dealt with? Only through association can this be done. You must proceed from the already known and interesting to the unknown and uninteresting. Where nothing already exists in the pupil's mind, from which a start may be made, the case is hopeless. Where there are no rational associations, as in the spelling of many words, many dates, irregular verbs, or none which can be discerned except by the expert philologist, or the historian who knows what other events happened and what people were alive in any given decade, there also the case is hopeless. No one should be set to teach such things so. But elsewhere the associations can always be found. That is why the most modern education, here and there, is so promising and delightful.

Where, for instance, science is taught to boys, beginning as Faraday began with his "Chemical History of a Candle," or as anyone may begin with the obvious facts of a boy's own body, interest is aroused and the rest follows, because we proceed from what is already interesting and make chains from it outwards. No man living, no devoted student, no "dry-as-dust" professor, would or could begin in the middle of any science. We must proceed by association from the near and vital, and then all will be vitalised. The dry-as-dust professor is just doing what the reader of the "Sporting Times" is doing—studying what interests him; only he has a long series of associations which we do not see. These are what sustain every student. He may be engaged in the differential chemistry of certain sub-molecules in the group of compounds called albumins, but he could never begin there, for it would be too heart-breaking and meaningless. He got there by a chain which began with a natural interest in eggs and milk and life and death; and he hopes that, some day, he will find the key to cancer along this line.

A Man's Worth Shown by what He is Interested In

Let no mistake be made, the man of science pursues his interests like everyone else. And the moral is that we should treat every learner on the same lines. If Newton and Darwin could not study gravitation or variation except by means of an approach, through association, which made these things vital to them, children and all learners must be treated as well. Somehow we must make the vital bridge, from daily experience or concern, outwards and onwards, until the child, or the philosopher, finds himself studying and remembering and searching among things which, in themselves, seem destitute of meaning or interest or worth. Thus the secret of self-development is the making of associations from vital things towards vital things, and the extension of our lives, and their creative power, into everything we touch with our minds. And thus we all reveal ourselves. The worth of any man, said Marcus Aurelius, is the worth of the things he is interested in.

WHEAT AND ITS COUSINS THE BEARDED BARLEY AND SPANGLED OATS

The plant shown below is the corn marigold. This photograph is by Henry Irving, and that on page 3119 is by courtesy of the Ontario Government.

IN PRAISE OF PLAIN BREAD

An Examination of the Cereals, and a Comparison of Their Different Food Values

WHEAT AS THE WORLD'S CHEAPEST FOOD

About milk, as we saw, there could be no doubt, and it deserved a place by itself, before we plunged into the welter of dietetic controversy. The value of milk as an article of human diet cannot be overestimated, as we have seen. Almost as much may be said for bread, which is indeed well worthy of its name, " the staff of life." And bread, like milk, presents to real statesmanship a national and social problem of high importance. So valuable a food is milk, so pre-eminent during the earlier—which are the more important—stages in the building up of any individual, that the establishment of a pure and abundant milk supply would be a greater national service than any, perhaps, which contemporary politicians have in view. As for bread, modern scientific botany offers suggestion and hope of a kind which will yield their fruit when all our contemporary arguments about taxation are forgotten. The new Mendelian wheats, created by Professor Biffen at Cambridge, and the demonstration that, by proper nurture, wheat can be successively grown in the same soil year after year, and the rotation of crops superseded—these mean more for national health than anything the eye of science can yet foresee.

Considered as foods, milk and bread, to which we here assign a place apart, are exceedingly different, above all because one is an animal food—so invaluable to the vegetarian—and the other is vegetable. Now, a great argument in favour of vegetable food in general is its extreme cheapness when compared with any kind of flesh, or even with cheese and milk. In round figures, and speaking generally, the cost of vegetable nutriment is about one-fourth that of animal nutriment. Foremost among vegetable foods are the fruits or seeds of certain grasses called cereals. Astonishing, indeed, is the dependence of mankind as a whole upon grass. Now, the most important of all the grasses is wheat, at any rate as far as Western civilisation is concerned, and this we usually consume in an elaborately prepared form as bread.

The question of cost is worth close attention. It directly affects every individual for whom the cost of living is a matter of any importance, and it is a national matter also, for to discover and obtain the best and cheapest food supply for a nation is a task of the highest kind. But these questions of the cost of food cannot be decided by the amateur, and, indeed, the expert is apt to be content when his inquiry has by no means gone far enough. At any rate, we shall here ignore mere weight of the food or alleged food under discussion, and shall look only at the weight of the actual nutriment which it contains. Thus estimated, bread is the cheapest of all foods—at present. Oatmeal runs it so close as to be practically as cheap, and will doubtless have the advantage in a few years. The comparison of bread with meat is also worth noting. A penny-worth of bread yields eight ounces of dry nutriment; a penny-worth of meat only four-fifths of an ounce.

This, however, is not sufficiently precise, for we require to distinguish between the different types of nutriment; and it is fair to look at the proteins alone, these being absolutely necessary for life. But even in terms of proteins, as distinguished from nutriment in general, wheat-flour is still the cheapest of all foods; and bread, though much dearer than flour, is still much cheaper than milk, meat, or eggs.

It appears that we pay the baker very heavily for his trouble, and that, so far as economy is concerned, it would be well worth while to bake at home. According

to Dr. Goodfellow, "Bread is one of the cheapest foods, not only with regard to the actual weight of nourishment obtained, but also with regard to the variety of the nutrient constituents; and the purchaser who expends his modest twopence-halfpenny on a two-pound loaf may rest assured that he could not spend his money to better advantage, except perhaps in the purchase of oatmeal, which contains slightly more energising nutriment than bread." If it be flour that is purchased, then the limit of economy has been reached. It will be evident that, as the population of the Western world persists in increasing at a rate which far exceeds that of the wheat supply, the fact that this is the cheapest of all foods will enter profoundly into the real economics of the next generation.

It cannot be said of bread, as it can of milk, that it is a perfect food—for man. No doubt the proportions of its constituents are perfect from the point of view of the young wheat plant, for which Nature designed it. Grass grows for its own sake, not for ours. Bread contains an excess, then, of energy-producing food, in proportion to its proteins, from which alone living tissue can be re-created.

The Need for Retaining the Germ of the Grain in Flour

We also need somewhat more fat than the proportion in bread supplies. Thus, as Dr. Hutchison points out, "we make puddings with eggs and milk, and eat bread with cheese, or spread it with butter." Evidently it is desirable that we should employ the methods of bread-making which involve least loss of the nutriment in the flour, and especially of those parts of it which are the more valuable and the less abundant.

There can be no question that those methods which do not involve the loss of the germ of the grain are a real advance in the making of bread. The various "germ breads," then, are to be commended, because they do really include the nutriment from the germ of the grain. We are entirely mistaken in admiring an extremely white bread—the whitest loaf is the starchiest, and the least rich in protein. Starch is a food, but very inferior to protein, which is the invaluable part of bread; thus, in general, the cream-coloured loaf is more valuable than the pure white one.

The public, however, has its own ideas on these subjects. It requires to have saffron, or what not, added to its milk, in order to remove its whiteness and make it look rich, but, on the other hand, we like our bread as white as possible. This has only the advantage of compelling the baker to be cleanly in his methods. The recent agitation in favour of "standard" bread was often used in order to permit of a relaxation of cleanliness and to encourage complacency with dirty flour—an unfortunate by-product of an excellent campaign. Once, however, we have satisfied ourselves that the departure from whiteness, on the part of a loaf, is not due to dirt, we should congratulate ourselves upon it.

The Disadvantage of an Excess of Moisture in Bread

Exactly what colour to aim at is a further question, but meanwhile we may note that the moisture of the loaf is not without importance. About four-tenths of an average loaf is water. There should be a limit to this, as in the case of tobacco or of milk. Indeed, legal limits should be put to the adulteration of many commodities with water. But, surprised though we may be at the usual proportion of water in bread, we should remind ourselves that, even so, it is much less watery than raw meat. We must note further, in relation to the colour question, that a brown bread is a wetter bread; and the purchaser of a brown loaf is buying such an excess of water that, in the upshot, he gets considerably less protein and less starch for a given cost, even though the brown flour does certainly include certain valuable parts of the wheat which the white flour omits. This point about the excess of water is unfamiliar to most people, but it entirely upsets the usual assumption. Of course, it does not apply to the choice between the purchase of white or brown *flour*, for those who make their bread at home.

The Superiority in All Respects of Crust Over Crumb

This water question further leads to the conclusion that the common opinion regarding the crust and crumb of bread is also erroneous. The crust is very much superior on all counts without exception, chiefly because it is so much drier. Only to consume the crumb of a loaf involves very great waste indeed. There are thus more reasons than one why we should make a point of eating our crusts, though the term "dry crust" is used almost as if it were equivalent to dry husk. The crust is dry because it contains so little water, which is another way of saying that it is in proportion more valuable. Also, it is very good for our teeth, and for

our children's teeth. It now seems to be fairly clear that one reason why our teeth are so bad is that we do not use them, an explanation entirely satisfying to the biologist, who knows that effort is the law of life, and that every organ, tissue, or function which has its work done for it—brain, stomach, tooth, limb; it matters not—inevitably degenerates.

Yet further, the crust of bread is much more digestible than the crumb, chiefly because it requires to be chewed, and is thus thoroughly mixed with saliva, which has all the better chance of doing its work because so little water is present in the first place. This is the sufficient reason why new bread, which is simply wetter bread, is less digestible. In a little while most of the water evaporates, and the task of digesting the bread is then simplified. It must be remembered that bread consists very largely of starch, the digestion of which is begun by the saliva of the mouth, but for which the stomach itself produces no ferment at all. If starchy foods are not properly mixed with saliva they simply get in the way in the stomach, and make no chemical progress until they reach the bowel.

The Highly Nourishing Properties of Toast, Rusks, and Biscuits

It should be added that cooked bread or toast is more digestible and no less nourishing than ordinary bread, this being still truer of the kind of toast called rusks. Biscuits, also, are highly nourishing in proportion to their weight, for they contain very little water, and the constituents added to the flour in making them are themselves valuable. Three pounds of biscuits are estimated by Professor Church to contain as much nourishment as five pounds of bread. Needless to say, these observations are all double-barrelled. They tell the economist and the emaciated what especially to employ, but they also give the too stout man hints as to what he should avoid.

Until recently, many people believed in brown as against white bread. For the moment we here confine the discussion to these two, not dealing with "germ" breads, or any bread made of cream-coloured flour. The principal feature which distinguishes real brown bread from all other is its inclusion of the bran. But the bran mainly consists of cellulose, which the human body does not digest in any appreciable degree, and this indigestible cellulose encloses (and therefore preserves) the other constituents of the bran. Two dogs and a hen between them were found to be unable to deal with bran effectively; and this experiment suffices to explain the fact that there is really no relation between the percentage composition of wholemeal bread and its nutritive value.

We live not by what we eat, but by what we assimilate. In this case, the cellulose is not only indigestible in itself, but a cause of indigestibility in other things. Thus the protein of brown bread is not absorbed as it should be, and even other foods, such as milk, when taken along with it, have their absorption interfered with.

Some Doubts About the Arguments for Brown and Wholemeal Breads

The fact is that the arguments in favour of wholemeal bread as against white bread were based merely upon chemical composition, and should have had regard to the behaviour of the bread in the bowel. The former medical practice of recommending the use of wholemeal bread by growing children and nursing women must therefore be abandoned. If wholemeal bread and wholemeal biscuits are now to be regarded as having any special virtue, apart from their pleasantness to many palates, it is that the bran they contain is somewhat of a stimulant to the bowel, so that they may be commended in constipation, in some but not all cases.

Brief reference has already been made to the importance of properly mixing the saliva with the bread one eats. The importance of mastication, upon which all recent dietetic and dental authorities insist, is very marked in the case of bread. It is largely because toast and biscuits and stale bread and crusts are dry that they are so useful. The teeth can work upon them, and they soak up the saliva, neither of which statements is true of new bread. Also, in the stomach, biscuits are found to be much more digestible than ordinary bread, and stale bread than new bread.

The Greater Likelihood of a Mixed Diet Giving the Body What it Wants

It is the general rule that vegetable foods are much less well absorbed than animal foods; but on the whole, and as compared with other vegetable foods, white bread is extremely well absorbed—best of all when it is taken, as it usually is, with other kinds of food. Indeed, everything goes to show that not only is man best suited by a mixed diet, but that, at any rate in health, he profits best by a mixture of foods taken at any one time. Much of the salts of bread,

including its iron, is unabsorbed; and an increase of the proportion of salt by the use of the bran of the grain is probably merely an increase in what is swallowed, not in what is used.

We have finally decided in favour of white as against brown flour. But so-called white flour may and does vary very widely in composition—a fact to which doctors have been drawing attention for many years. Thus Sir Lauder Brunton used to have an amusing and ingenious explanation of the superiority of American dentists—a superiority, by the way, which is arguable, as we shall later see. It was that the American dentists are the best because Americans are so clever in the manufacture of machinery. Good machinery means white flour, lacking in protein, not properly feeding the teeth; hence bad teeth, and hence good dentists. Recent inquiry has been specially directed to the difference between the various grades of "white" flour, and the opinion has been abundantly confirmed that "seconds" flour affords more value to the body than "patents." The bread made from "seconds" flour is richer in protein, but is darker, and is therefore erroneously distrusted.

Obscure Qualities in Foods that Give Them a Special Value

However, in the course of special study of this question of the kinds of flour, it was shown that what is now often called "standard" flour has a superiority which is not to be explained solely in terms of its excess of protein. If some such percentage of superiority were all it could boast, a slight increase in the amount of "patents" consumed would put things right. But that appears not to be the case. The fact is that the darker flour contains a substance, or perhaps a series of substances, which have a specific virtue of their own in relation to nutrition, but which are absent, or nearly absent, from the whitest flour. We cannot name or define these substances, nor can we allot them to any of the great classes of foodstuffs which we first found exemplified in milk—proteins, carbohydrates, fats, and salts. But that merely shows how inadequate our knowledge of dietetics still is.

The fact is that this recent discovery regarding the wheat-grain is only one of a large number, all of which point in the same direction. The study of milk taught us that there are certain great classes of foodstuffs, necessary or very desirable for health. But we also learnt that there seem to be some obscure substances in milk that cannot be called foods, on the ordinary physiological definition, but yet are very desirable for health. Lately much light has been thrown on a long-mysterious disease called beri-beri, which seemed to have some connection with diet. Now, it appears that the disease is due to the loss from the diet of a substance which is contained in the skin of the rice-grain; and when that substance is restored the disease disappears. A far older instance, still obscure, is that of the well-known disease scurvy, which for a long time barred the path of mankind to the North Pole.

The Mystery of Scurvy and Its Equally Mysterious Cure

Here is a disease from which we are all prevented by something which we take in an ordinary diet, but which we cannot define, and which is not a food in the ordinary sense of the word, according to the long-accepted physiological definition which we shall shortly study. When sailors are deprived of fresh fruit and vegetables, though they are well fed on proteins and carbohydrates and so forth, they are liable to suffer from scurvy, a disease of nutrition which has its parallel in the "infantile scurvy" of improperly fed infants. But the regular supply of such a substance as lime-juice, which is not a "food," and does not answer to any of the physiological ideas of a food, is sufficient to prevent the disease.

Such facts as these point to a realm of dietetics about which we know practically nothing as yet, but which must lead us to be very cautious in our assumptions, hitherto confidently made, that we can really estimate the value of any diet by making chemical analyses of the protein, etc., that it contains. All the time we may be overlooking some really essential ingredient, the existence of which can only be inferred from the disastrous consequences which follow its withdrawal from the diet.

Valuable Forms of Wheat that are Known Under Other Names

This is far too big a subject to be dealt with incidentally here, but we have already seen enough to make us realise that the superiority of bread made from flour which includes much of the germ of the grain may be not merely relative, but absolute, in that such flour contains certain specific substances, peculiar to it, which somehow enable us to make the best use of the rest of our diet. Wheat is such an invaluable foodstuff that we should be acquainted with the various forms, other than bread and biscuits,

in which it is presented to us. These include semolina, macaroni, vermicelli, Italian pastes, shredded wheat, "Force," and "Grape-Nuts." Not every housewife knows that the first three of these are really wheat-flour, and therefore rank specially high in the dietetic scale. There is an immense interval, for invalids and children and everyone else, between such substances and, for instance, arrowroot, a favourite invalid food of the past, which practically consists of nothing but starch, is scarcely worth eating at any time, and is certainly a mockery for invalids. As for the last two preparations named, these are whole-wheat preparations with malt, easily digestible, very cheap, and highly nutritious, the latter especially.

Wheat, we have seen, takes first place among the cereals, but its relatives may conveniently be dealt with here also. Oats, for instance, are a very valuable source of food. Growing as they do in the North, they are somewhat rich in fat, for such a useful source of heat is required for the purposes of a young plant that is to grow in high latitudes. Thus, oats are rich in fat; while rice, which grows in warm climates, is poor in it. Hence, both on account of its fat and because of the irritant and innutritious husk, ordinary oatmeal is not a very suitable food for those whose digestion is delicate. The consumer of ordinary oatmeal porridge who finds his digestion troubling him should give it up. Some of the recent rolled oats, however, such as "Quaker Oats," and others, are more easily digestible, though the method by which they are prepared somewhat reduces the nutritive percentages in the product.

By those whose digestion is good, oatmeal porridge is very well absorbed, and it has doubtless played a great part in the history of Scotland. The remarkable average size and strength of the Scotch may very well be associated with this staple of their diet. But, unfortunately, jam and tea have lately begun to replace porridge in the diet of the labouring classes in Edinburgh and other Scottish cities; and the products of this diet promise to be not the largest but among the smallest of men and women.

Another excellent cereal, maize, or Indian corn, agrees with oats in not containing the glutinous ingredient by which wheat flour can be made into bread; but Dr. Robert Hutchison, who has a high opinion of maize, points out that the "Johnny cakes" of North America, which are made from it, compare very well indeed with good white bread. In this country we are familiar with the product of maize which is called cornflour. But unfortunately cornflour is made from maize by a process which leaves practically nothing but its starch, a food of minor importance, and certainly no serious food for invalids. Cornflour, therefore, must be bracketed with arrowroot, these being foods of which modern knowledge entertains no very high opinion, especially in relation to invalids. Also, of course, neither of them should ever be given in any form to infants, who can digest no form of starch.

SHREDDING INDIAN CORN IN THE FIELDS OF ONTARIO, CANADA

Maize is very well absorbed, highly nutritious, and just about as cheap as wheat. Its introduction into Ireland at the time of the potato famine, some sixty years ago, was a real boon. Dr. Hutchison declares with great force that "in view of these facts, and of the approaching scarcity of wheat, one cannot help a feeling of regret that maize is not more widely adopted as food amongst the working classes of this country." We may best respond to the "bitter, agonising cry" of Europe for cheap bread "by instructing the toiling masses of the Old World in the excellence and cheapness of maize, and the proper methods of preparing it."

Barley is another important cereal which is of very considerable nutritive value, though it is inferior to wheat. Loaves made half and half of wheat and barley-meal are an excellent article of diet, however. There is no appreciable nourishment

in barley-water, which is, nevertheless, an excellent drink in its way.

Last, but not least, in this list of the cereals comes rice, the grass which supplies food for more of mankind than any other; indeed, it is said to be the staple food for one-third of our species.

The Inferior Character of Rice, and Its Possible Effect on Civilisations

Though it agrees with the other cereals in general, it is distinctly inferior to them. We have already seen that it is relatively poor in fat, of which the young embryo needs less in a hot climate. But it is also very poor in protein—say about one-third as well provided in this respect as wheat. Indeed, we have to look upon rice as mainly a starchy food, barred, of course, to infancy. This also means that, for a proper diet, rice must be supplemented by other substances, richer in the protein or nitrogenous constituents. Several years ago, the celebrated chemist Sir William Crookes, in his Presidential Address to the British Association, discussed this question. He argued that the difference between the nutritive properties of wheat, on the one hand, and rice, on the other, may go far to account for some of the most salient differences between Western and Eastern civilisation, especially in regard to their relative activity. It is, indeed, not certain that our civilisation could be founded upon rice; and it is not even certain that its world-supremacy can be maintained if the world-supply of wheat should prove inadequate for the people of the temperate zone.

Rice, no doubt, has its virtues, especially when it is understood. It is best cooked by steaming. The Italians, into whose country rice was introduced a few centuries ago, do well to eat it in the form of what they call "risotto," for then they take eggs and cheese with it, which supply its relative defect in proteid. But, at its best, rice cannot be compared with wheat, which remains easily the first of all cereals.

Wheat the Irreplaceable and Indispensable Food for the Maintenance of Civilisation

Apart from a proper supply of milk, a proper supply of wheat-flour is an essential for the healthy life of any modern nation. We have seen the evidence that this food occupies a special place, in virtue of its richness in the most valuable ingredients of a diet, both those known and those unknown, and in virtue of its remarkable cheapness in proportion to its nutritive power; and we may add that it is also to be valued for the absence of any ingredients which are poisonous or dangerous, nor is it liable to contamination or infection. On these very special and cogent grounds the hygienist is bound to say his say on a current political question, by no means in order to take sides, but in order to insist that both or all sides are right when they place the ensurance of a large and abundant supply of wheat in the forefront of their programmes. The hygienist strays beyond his province if he begins to discuss methods, but he is entitled to say that in his scientific judgment wheat is an irreplaceable and indispensable food for the maintenance of any such civilisation as ours.

Further, the prophecy of Sir William Crookes, now not far short of two decades old, is being rapidly and surely justified—the supply of wheat from across the Atlantic is about to come to an end.

The Necessity for Providing a Sufficient Wheat Supply in the British Isles

In these circumstances it becomes a plain necessity of national policy that as much wheat as possible should be grown in our own country, if our present population is to be maintained in health in the near future, to say nothing of any increase in its numbers, such increase now depending upon a supply of foreign wheat which is running dry.

On this matter science makes definite contributions. First, physiology lays it down that the cereal to grow, wherever it can be grown, must be wheat and none other, for it will certainly maintain more life and health than any other. There is national loss of life wherever any other crop grows where wheat might be growing. Then, as we already know, Mendelism makes its contribution in the form of wheats which can be successfully grown in this country, are immune to rust, and produce the "strong" flour which bakers like best. For years now this possibility has been demonstrated in the experimental farm of the school of agriculture in the University of Cambridge. Thirdly, the students of plant physiology, notably such men as Mr. A. D. Hall and Dr. E. J. Russell, his successor at Rothamsted, have shown us how wheat may be grown, and in successive years, where formerly this was impossible. The politicians who, by whatever devices seem suitable, can enable science thus to serve the cause of national health will be good friends of the people. But in discussing these political questions,

from whatever point of view, the physiology of nutrition must not be ignored. The moment that the politician uses the word "food" he comes under the judgment of science, the business of which is to examine such a word, and to distinguish sharply between various articles of popular consumption in terms of their food-value.

The Difference Between Taxing Wheat and Taxing Less Essential Things

Primarily, as we have seen in another section of this work, the "struggle for existence" is a struggle for the food supply, and this applies to nations as well as to species. But it is necessary to distinguish, in the significant old phrase, "that which is not bread." For instance, in the matter of taxation, the nutritive values of articles consumed must be considered. There are those who try to persuade us that a tax on wheat, though it is a tax on food, will be compensated for by a reduction in the tax on other commodities, such as alcohol, tobacco, tea, and coffee; or that we need not be concerned about a tax on food, since these things are taxed already. But none of these four things has any food-value at all, whereas wheat is the "staff of life."

The present writer has no competence or title to discuss the incidence of taxation; perhaps a tax on wheat might serve the cause of greater wheat-production in this country, which he desires, but he is entitled to enter a demurrer on the part of hygienic science when he finds, let us say, wheat and tea put on level terms as foods in this connection.

Open to no argument, however, are certain political possibilities, especially in relation to the work of the Board of Agriculture, which would serve the cause of a good and abundant and secure wheat supply for our people.

The Wisdom of Teaching the Value of Wheat Foods as Part of National Education

And our scheme of national education should comprise the study of food-values. Girls should be taught cooking and baking; and these subjects should be associated with the study of domestic economy in relation to food-values. The cause of health would be greatly served by just such a simple reform in education as would teach the women, and especially the mothers, of the nation to spend their money more on wheat and its products and less upon such things as cornflour and the inferior cereals, to say nothing of meat, which yield no such nutritive return as wheat for a given expenditure

One extreme case—whatever may be the appropriate treatment for it—requires to be insisted upon in the light of recent chapters. It may be briefly summed up in the antithesis, "Wheat or whisky?" Under present conditions, which cannot possibly persist, it is more profitable, in many parts of the country, to grow inferior cereals for the sake of their starch, to be converted into alcohol, than to grow wheat. Those conditions are clearly vicious, and must be repaired in the national interest, partly, perhaps, by suitable political methods, and certainly with the aid of recent scientific knowledge. But when we see barley growing for the production of whisky where wheat might be growing, and was actually grown in the past, we must realise that, from the national point of view, this is madness. The population of these finite islands increases by over four hundred thousand every year, and every one of these persons requires an adequate supply of wheat. The life of none of them can be sustained for a day upon whisky, the national cost of which in death and disease is beyond reckoning.

The Economic Use of Sunlight in Turning It Into Wheat

Our national income is sunlight—most of the rest of what we spend, such as coal, is capital. Strictly speaking, every ray of sunlight, which is actual physical energy, should be turned to the purposes of our lives. In no other way can this be done so economically and efficiently as by the growth of wheat for bread—that is the definite verdict of hygienic science. The same science now condemns the use of alcoholic spirits altogether. The choice between wheat and whisky is a choice between life and death; and our successors will say that our present preference for the growth of whisky over hundreds of thousands of acres which might have been growing wheat was nothing less than a prostitution of sunlight.

In due course hunger will put a stop to this. As our numbers increase, and the supply of wheat from overseas becomes steadily more expensive, great areas of our land, hitherto employed for pleasure or ostentation, or simply neglected, gely assiduously cultivated for the growth bles. crops which produce only disease sun- death, will of necessity be turned to t sorts beautiful, rational, vital function of large ducing, as they so easily might, the ORCES national and individual life.

FOOD FROST-GUARDED PAST THE TROPICS

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...en meat brought across the world must be handled expeditiously between the ice-chamber of ...nd the ice-chamber of the store. It is unloaded with great celerity by means of an endless ...chanism, which carries carcases in quick succession from hold to wharf, in its iron claws.

THE CONQUEST OF DECAY

Man's Battles with the Microbes for the Preservation of His Food

THE TRIUMPH OF ARTIFICIAL COLD

It is doubtful if anything has affected the economic conditions of our country in recent times so much as the discovery of means of preventing the decay of foodstuffs. Next to the railway and the steamship, the refrigerator has perhaps done more than any other modern invention to benefit our vast industrial population.

Indeed, without the new methods of sterilising, chilling, and preserving meat, butter, fruit, vegetables, fish, milk, eggs, that are now practised, our working people could not properly be fed. Extreme fluctuations in the supply and price of the principal provisions would be frequent, and a large number of the labouring classes would be subject to recurring periods of misery. But on the foundation of a few simple inventions a magnificent industry has now been built, by means of which foods produced in countries where there are insufficient people to consume them are carried and delivered in a fresh condition to hungry and overcrowded nations. The sheep-runs of New Zealand and Australia, the cattle-farms of the Argentine and Brazil, the orchards of the West Indies and California, and the dairies of Siberia have been brought practically to our doors.

And all this is the result of an easily won victory over the germs of decay. The microbe is a useful scavenger. But for its incessant and universal action our earth would be buried in the ruins of life. Everything that died would rest on the ground, encumbering and stifling all the younger growth of our planet. Forests would be but a mass of fallen trees, through which no young, green shoot could pierce. Fields would be blanketed with dry, withered grasses and dead plants; and even the flesh of the mammoth of the great Ice Age would not have perished yet from its bones. It is the microbes that clear all the dead growth from the earth, and keep a large, clear path for succeeding generations of plants and animals. It would be disastrous to interfere on a large scale with the work that they are doing, but from the earliest dawn of civilisation man has been compelled to fight them continually for the preservation of his food supplies. Every time that he has tried to store the abundance of one season against the need of a time of scarcity, he has had to fight against the innumerable germs of decay that fill the air with their invisible armies, and occupy all the seas and lands between the ice-bound region of the Poles.

So, from the earliest ages, the hunting savage has dried and smoked and salted his meat and fish. Pastoral races have found a way of preserving the milk of their cattle by making it into butter and cheese; farmers have discovered a means of preventing their grain from rotting by keeping it from becoming moist; and housewives have learnt to pickle certain vegetables, and make sugary syrups to conserve fruits. Drying is the most natural and oldest process of preservation. In Nature, the germs of seeds and nuts are protected from the agents of decay by their dryness. The microbes that bring about decomposition are a very low kind of plant, and, like all vegetable life, they need moisture to grow and multiply. So by drying meat the Boers make their biltong, and the Red Indians their pemmican. And several great modern industries use the drying process in making extracts of meat and preparations of evaporated milk, which can be kept for a long time.

The method of desiccation is also largely used in preserving fruits and vegetables. The best results are still obtained by sun-drying; and the bottlers of the finest sorts of Bordeaux plums would pay a large

sum of money to any man who could invent a speedier artificial means of desiccation that would not harm the flavour of the fruit. Heated air and vacuum drying are employed on a very large scale, but the flavour of raisins and prunes prepared in this manner is inferior to that of the sun-dried plums. And for the last sixty years fruits and vegetables have been preserved in enormous quantities by various evaporation processes.

The Preservation of Food by Harmless Chemical Antiseptics like Salt

Next in date of origin to the drying of food is the use of some chemical with antiseptic qualities. Here salt is generally employed, by reason of its power and cheapness. It has the valuable property of being a germ-killer, and yet healthful to the human system if used in moderation. Certain fish and meat can be cured and preserved simply by packing and drying, but in many cases, after salting, the smoke of a wood fire is allowed to play on the meat. This is also one of the ancient methods of savages, and all our finest hams are still prepared by means of it. It is creosote in the smoke of the wood fire that is the chief preservative; and though the creosote from wood smoke itself is a harmful chemical, it does not seem to make the pork treated with it indigestible. In fact, there has recently been a general change in the public taste in regard to bacon. Old-fashioned salt bacon is certainly a more healthy food than the smoke-cured variety, but nowadays many persons have acquired a dislike to the old salt flavour. This has led to the use of boric acid as a preservative, with the result that the favourite breakfast dish of the nation is, in many cases, much less wholesome than it used to be.

The Preservation of Food by Injurious Chemicals like Boric Acid

Since Pasteur discovered that the decay of food was directly caused by the action of microbes, there has been too large and injurious a use of chemical antiseptics. The substances employed chiefly consist of boric acid, borax, and mixtures of these two drugs; salicylic acid, formaldehyde, and sulphurous acid and sulphites. Boric acid or borax is much used in milk and butter and cream, in bacon, ham, poultry, and in fish and potted meats. Salicylic acid—a dangerous drug—is often found in temperance drinks and intoxicating liquors, in jams and preserves. Formaldehyde is coming into fashion as a meat preservative. Not only is it a poison, but it combines with a certain substance in the meat to make the food indigestible.

It is estimated that in the course of a single day a consumer of food bought in our great cities takes a heavy dose of boric acid, and that this is one of the main causes of the increasing stomach troubles and the consequently irritated nerves of the present generation. Moreover, by the use of modern chemical preservatives it is possible to make a food appear fresh to the ordinary observer when, as a matter of fact, decomposition has proceeded up to a certain point. The practice of adding drugs to food is adopted by certain manufacturers and vendors for the purpose of avoiding the expense of proper appliances to ensure cleanliness and scientific preservation. The use of chemical preservatives is no longer necessary for the production or preparation of food as articles of commerce.

For modern science has discovered two additional ways of preventing decay. By the first methods the germs that do the mischief are destroyed by heat; by the second method they are frozen into powerlessness. Well-cooked food is more wholesome than raw food, for the reason that the high heat to which it has been subjected has destroyed practically all the germs of decay and disease.

Napoleon's Prize for Sterilisation of Foods, and the Invention of Canning

By cooking meat until it was sterilised, and then covering it up so that no new germs could infect it, a French inventor, Nicholas Appert, discovered in 1795 the principle of the modern canning industry. So important was the discovery from a military point of view that Napoleon gave Appert a prize of twelve thousand francs for his invention. It solved the chief problem of modern warfare—the problem of feeding an army. Appert used glass and china jars, which are still the best of all possible materials for keeping sterilised foods in. But their fragility and expense prevented the canning industry from developing in a large way; and it was not until the invention of the machine-made American tin can that the food supplies of a large number of poor people were increased by the canning process.

In a modern canning factory the food is cut by machinery into pieces the length of the can. It is then sorted out and placed in a cheap metal vessel, after which the caps are soldered on. In each cap there is a vent-hole for the escape of steam and gas during the cooking process. The cans are

placed in a steam-boiler, the cover of which is bolted down, and the steam is then turned on. It sterilises the contents by heating them, under high pressure, to a temperature that kills the germs of decay. The cans are finally sealed down hermetically by placing a drop of solder over each vent-hole. In this way various kinds of meat and made-dishes and soups and sauces are preserved, so that they can be sent to the most distant parts of the world.

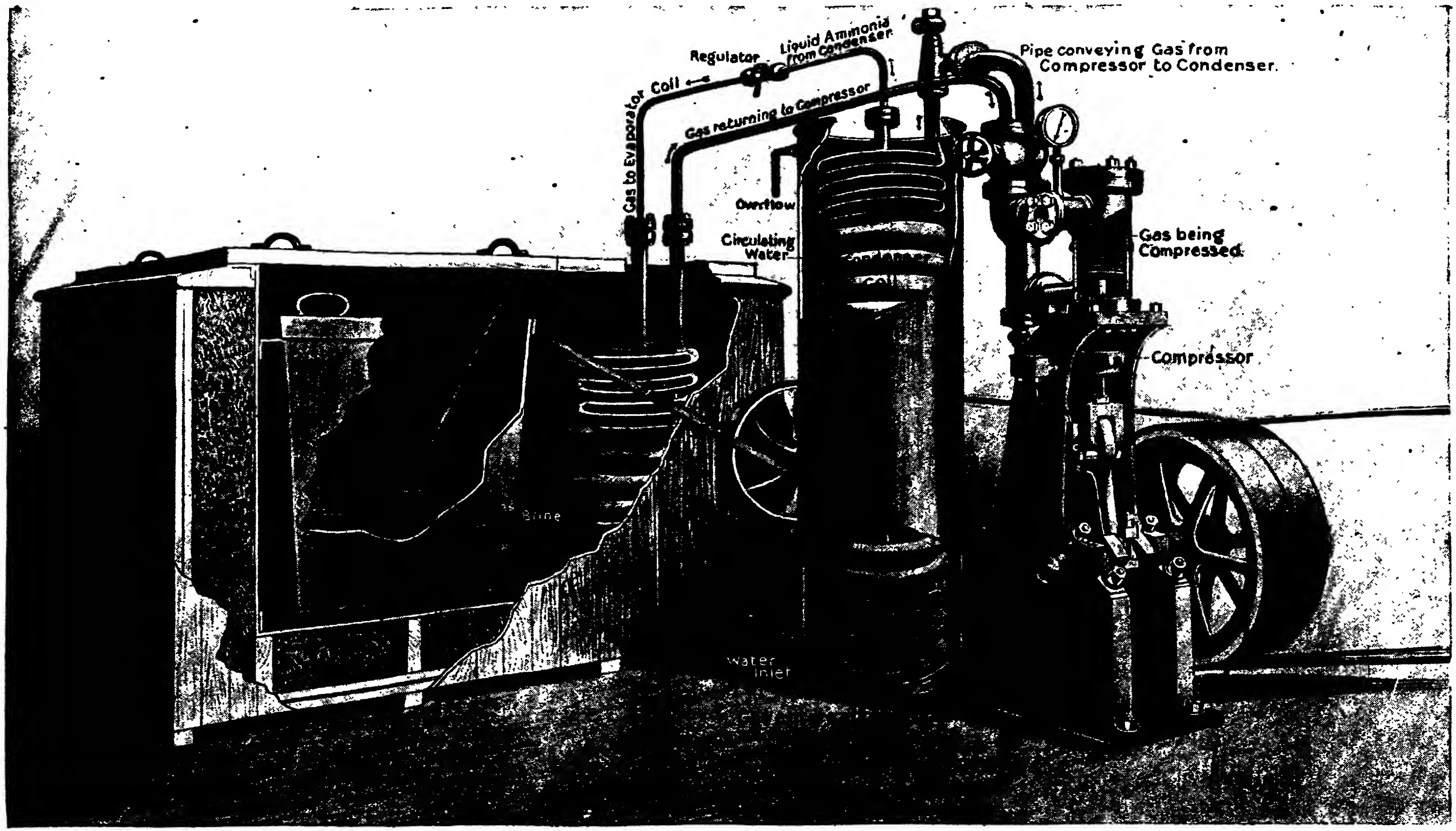
The canning of fish requires more care than the sterilisation of meat and vegetables. The process of natural decay is more rapid. In a salmon cannery the fish is first washed in an ice-cold bath, and then dressed and washed again. Machines cut it into pieces, and it is placed in the can, and subjected to so intense a heat that even the bones are cooked so that they will crumble. For this first cooking the cans have been lightly soldered; they are now tested by the venting process, which consists of making a small hole through which the steam escapes. If this is satisfactory, the can is then placed in a second steam-heated retort for final cooking; and after a lye-bath, to remove any grease, it is lacquered and labelled.

A considerable amount of serious and mortal illness has been traced to the use of canned food. The ptomaine poisoning is sometimes attributed to the action of the acid of the sterilised food on the interior metal of the can. It is doubtful, however, if canned food can take up sufficient tin to produce any harmful results. It is more likely that the presence of the poison is largely due to imperfect sterilisation. This is certainly a danger in the case of large tins which have been cooked carelessly or hurriedly. In spite of the high temperature of the steam-heated boiler, the can is not always subjected to the heat for the full time necessary to destroy all the germs. Some of the spores of microbes have a curious covering that enables them to stand extremes of heat and cold, and then grow and multiply when the process of sterilisation is over. This is why a small tin of canned food is safer to eat than a large tin.

DRYING RAISINS IN THE SUN AT MILDURA, AUSTRALIA

In other cases, the food may have been tainted before the canning process—quite a possible thing in factories that only can the inferior parts of animals, under conditions that are not remarkable for cleanliness and for the scientific examination of the slaughtered beasts. But where the process of sterilisation is carefully carried out, and especially where glass or china vessels are used instead of tin cans, there is no practical danger of the consumer dying from ptomaine poisoning. He runs much less risk than a child does who is brought up on boric-acid

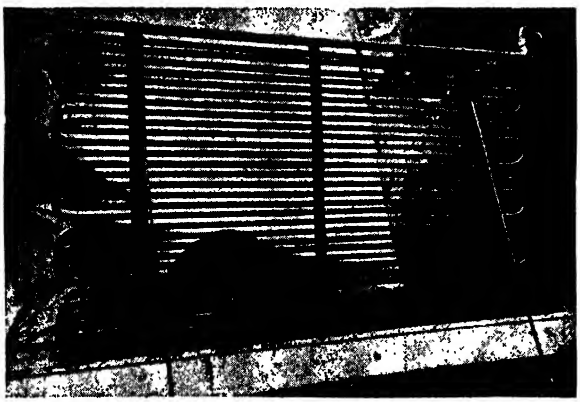
MAN'S MECHANISM FOR DOING THE ICE-WORK WHICH WINTER CAN DO SILENTLY IN A NIGHT



This picture-diagram shows the principle of the refrigerating machine, as applied to the manufacture of ice, the object being to cool brine, by the evaporation of liquid ammonia in coiled pipes, sufficiently to freeze the fresh water in a can submerged in the brine.

milk, formalin-vapoured meat, and salicylic-acid jam.

No risk whatever is run in eating food that is conserved by the latest and largest and most scientific method—the method of refrigeration. It is estimated that meat to the value of £300,000,000 sterling is now conserved every year by means of artificial cold, and other articles of food of the same annual value of £300,000,000 sterling are also refrigerated. Yet, in spite of these extraordinary figures, this most important of modern industries is still in its infancy. When it is fully developed it will cover, in some way or another, the larger part of the food supplies for all the nations of the civilised world. Every shop for the sale of fresh provisions will have a cold-storage room; every railway train and steamship carrying things liable to decay will have refrigerating-cars and refrigerating-holds; and the pantry of every decent house will contain some small, cheap machine for manufacturing artificial cold. When all this is accomplished the use of injurious chemical preservatives will be entirely abandoned, and the health and means of nourishment of all classes will be greatly advanced. This is not a dream of the far future. Some happy inventor of a cheap and simple refrigerating-machine may bring it about in a few years' time.



A SET OF PIPES IN WHICH LIQUID AMMONIA EVAPORATES AND COOLS THE SURROUNDING AIR

At present, the scientific systems of refrigeration are rather too costly for domestic use. They are very economical when worked on a large scale, with a steam-engine or a gas-engine to drive the pump; but for home purposes the old-fashioned ice-machine is, in spite of its defects, the handiest instrument. The principle on which it works is very old. It is based on the fact that when a piece of solid matter is converted into a liquid it absorbs heat from its surroundings. When a bottle of wine is placed in melting ice, the ice does not give its coldness to the wine, but in melting it robs the wine of heat. The process is a chemical one. In its simplest form, the ice-making machine consists of a wooden tub, into which is placed a vessel containing the substance to be cooled. Between the freezing-vessel and the tub is packed some chemical mixture, such as ammonium nitrate and water, or calcium chloride; or pieces of solid ice may be used. When the chemical salt is dissolving in the water, it has the curious property of absorbing heat. The mixture is, in fact, greedy of heat; it steals it away from the interior of the freezing-vessel, which it surrounds, so that the substance in the vessel becomes frozen.

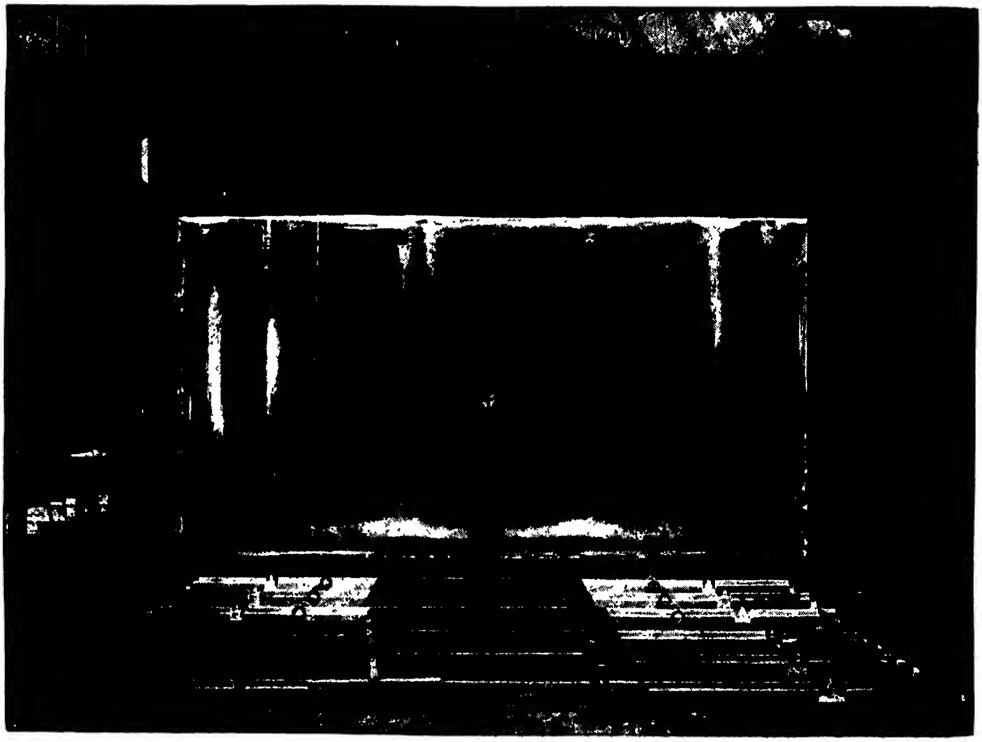
A good deal of ice is still made on this principle, especially by means of an improved apparatus consisting of a series of hollow vessels that fit into each other. Between each vessel space is left for the chemical mixture to circulate. The result is that the outermost vessel cools the second, the second robs the third of its heat, and the third the fourth; so that the cold is intensified at the centre, where the vessel containing the water to be frozen is placed. The series of vessels is fitted into a wooden outer casing, and so mounted as to be capable of being slowly revolved, thereby promoting the more rapid dissolution of the salt, and consequently the abstraction of heat from the innermost freezing-vessel. In spite, however, of its simplicity, this chemical method of producing coldness by liquefying a solid is expensive, and cheaper mechanical means are generally employed in all the chief refrigerating industries.

We have seen that when a solid is being transformed into a liquid it eagerly takes up heat from everything that surrounds it. The same thing occurs when a liquid passes into a gaseous state, or when a compressed gas expands into a lighter condition. One of the chief troubles of a compressed-air engine is that as the air expands it chills the pipe through which it passes. When the compressed air flows through a long pipe, expanding as it flows, it often deposits a frost on the machinery that it drives. In all engines in which heat is used for mechanical work, the loss

of efficiency through the chilling effect of the expanding gas is a difficult problem which the engineer has to solve. But this difficulty is transformed into a convenience in the refrigerating-machine. Here heat is used to produce cold. In an ice-factory coal goes in at one door and ice-blocks come out at the other.

This paradoxical effect is obtained by using the coal to drive a pump, and by making the pump compress a gas into a liquid. The liquid runs through lines or coils of piping, and expands once more into

In practice, only machines working on the direct expanding system act in this manner. More often, the pipes containing the expanding gas are immersed in brine; and the brine, which has the property of absorbing a high degree of coldness without congealing into ice, is circulated through another system of pipes in the actual refrigerating chamber. But in all cases the fundamental principle is the same. Some gas is compressed by mechanical means into a liquid, and then this liquid is allowed to expand back into a gas.



A MONSTER SHEET OF MANUFACTURED PLATE-ICE, OVER A FOOT THICK

Flat hollow walls of galvanised sheet iron are placed in a large wooden tank, which is filled with the water to be frozen. Cold brine is circulated through the hollow walls, causing a plate of ice to be formed on each side of them, the water being agitated by means of compressed air. When the plates of ice are 12 or 14 inches thick the cold brine is shut off and warm brine pumped through the walls, so as to loosen the ice and permit of its being withdrawn from the tank by a crane, as seen in this picture.

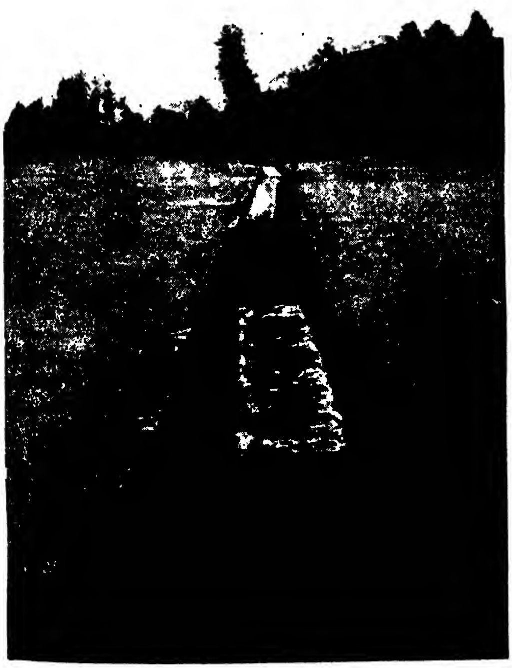
a gas. The result is that the pipes grow intensely cold, for the expanding gas robs them and the surrounding air of heat. If there is any moisture in the room through which the pipes run, it is turned into falling snow, simply through the extraordinary heat-absorbing powers of the expanding gas. When the gas has finished its travels through the piping, it returns by means of a valve to the compressing-chamber, and there the descending piston again presses it into liquid form and sends it back into the pipes to resume its work.

During this process it robs of heat everything with which it is brought into contact.

At the present time there are three principal types of refrigerators in which a gas is compressed and then expanded. They are distinguished by the kind of gas with which they work. In one, ordinary air is compressed. In another, carbonic acid, which is comparatively harmless in a case of leakage, is reduced to a liquid state and then vapourised. In the third kind of machine an ammonia gas is compressed and liquefied and expanded. This gas

THE ICE TRADE IN ITS NATURAL HOME

SAWING ICE INTO BLOCKS ON A NORWEGIAN RIVER

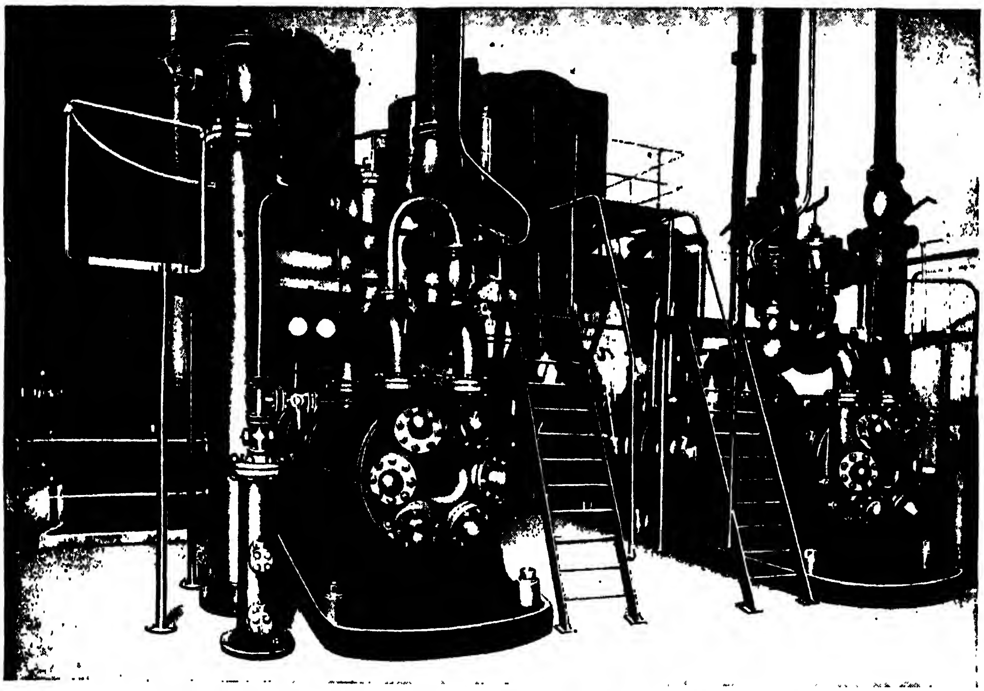


ICE TRAVELLING TO A COLLECTING DÉPÔT BY WATERWAY AND SKIDWAY

is somewhat inflammable, and when mixed with about twice its volume of air it is capable of exploding with considerable violence. It also has a very strong action on copper and on alloys in which copper is used; so none of these metals can be employed in making any part of an ammonia-machine. On the other hand, ammonia gas possesses more heat-absorbing power than any other refrigerating agent, and it liquefies at a comparatively low pressure. For these reasons it is generally reckoned the most efficient and cheapest-working, and it is used in a very large way.

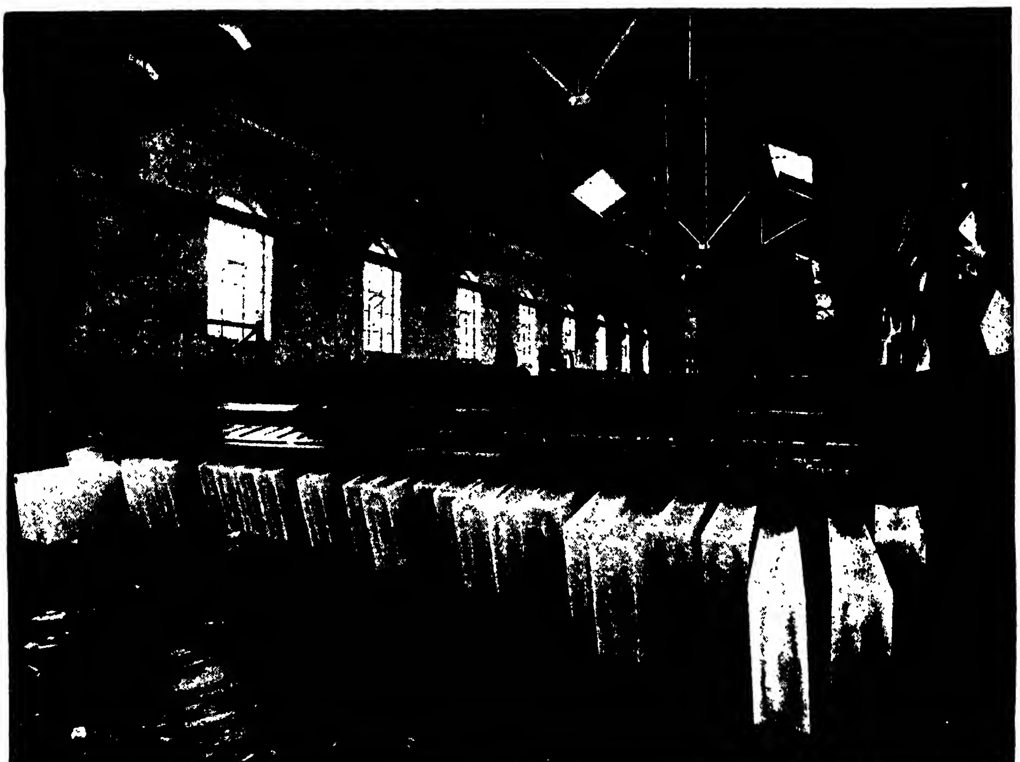
The most important part of an ammonia-machine, and indeed of all refrigerators in which a vapour is transformed into a liquid, is the gas-compressor. It consists of a piston working in a cylinder by means of a steam-engine or other suitable motor—in fact, it is a kind of pump. By its first stroke it sucks in the gas that has expanded in the evaporating coils or pipes. On its second stroke it compresses the gas, and forces it into the coils of a condenser, where under the cooling action of water the gas resumes its liquid form. The liquid then passes through a minute opening into the evaporating coils or tubes, where it instantly flashes into gaseous form, and so performs its work of absorbing heat from surrounding objects. These objects in the present instance are either the pipes in the refrigerator and the brine that circles round them, or, in the direct expansion system, the sets of refrigerating pipes and the air of the cold-storage room.

One of the chief difficulties in all gas-compressors is the prevention of leakage of gas past the piston-rod. For if there is no leakage the gas can be used over and over again, thus saving the expense of continual new supplies of ammonia. Moreover, the danger of fires and explosions and lesser disasters is avoided. So the box through which the piston passes in its sucking and its pumping and compressing movements is filled with various kinds of air-tight packing; and in many cases oil is pumped at every compressing stroke into the stuffing-box, sealing it up so that no gas can possibly escape. It is subsidiary devices such as this that increase the intricacy of construction of a great refrigerating-machine. But this intricacy is more than compensated by the additional efficiency of working that is thereby attained. Yet each improvement made in these very powerful machines takes them away from the field of small domestic



THE LARGEST SINGLE REFRIGERATING-MACHINE IN ENGLAND, MAKING 200 TONS OF ICE A DAY AT GRIMSBY BY THE AMMONIA PROCESS

FILLING WITH WATER A ROW OF CANS IN WHICH ICE IS MADE BY REFRIGERATING MACHINERY

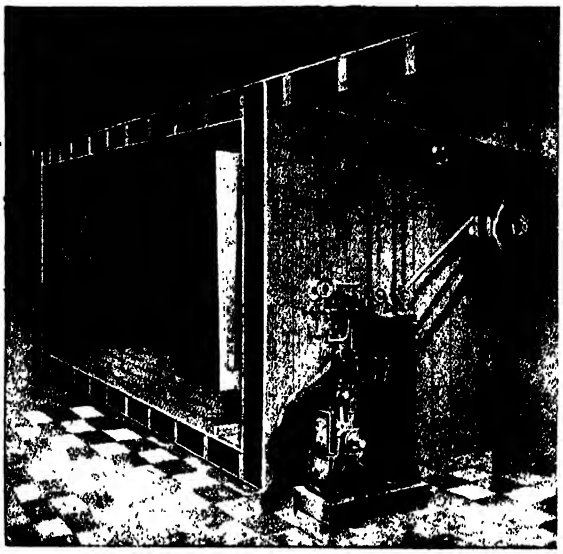


TIPPING A ROW OF ICE-BLOCKS FROM THE FREEZING-CANS BY MACHINERY

These photographs and others on these pages are by courtesy of the Linde British Refrigerator Co. Acknowledgment is also due to Messrs. West and Benyon and the Pulsometer Engineering Co.

purposes, though perhaps, where electricity is unusually cheap, a small dwelling-house refrigerator on the compression principle could be used.

Lately, however, a fairly efficient refrigerator has been constructed in which artificial cold is produced by the direct action of heat, without the use of mechanical power. It is chemical in action, like the small, old-fashioned ice-machine in which coldness is produced by the liquefying of a solid. In this case, however, a liquid is used—usually ammonia. The process is founded on the fact that water possesses a great capacity for absorbing a number of vapours with low boiling-points; and by reason of their low boiling-points the vapours are easily separable from the water by heating the mixed liquid. Hence the method is commonly known as the absorption process. The ammonia liquid is poured into a generator, and there converted by heat into vapour. In the best machines this vapour is then free entirely from water, and passes into the refrigerating coils. Here it expands and does its work of producing artificial cold. It next passes from the refrigerator back into the generator, where it is absorbed by water. Then this watery mixture is again heated and made to give off ammonia vapour; and so the cycle of operations is continually repeated.



HOW COLD AIR CIRCULATES IN THE REFRIGERATING-ROOM OF A SHOP

In some exceptional cases machines of this kind have run for three years without needing a new supply of ammonia. But in ordinary practice a little leakage is unavoidable. Yet, as the price of liquid ammonia is only 3d. to 4d. a pound, the expense is not great. Where exhaust or waste steam can be used in heating the generator, and the ammonia-pumps can be driven economically, the absorption process is very economical. If there were a large demand for small machines of this sort for domestic purposes, some inventor might be induced to design a simple apparatus connected with the general electrical supply, and heated with an oil-lamp, for ordinary family use.

In the meantime, a cheap and abundant supply of liquid air would make the domestic refrigerator a practical success. Some time ago an English company for the manufacture of liquid air calculated that with a plant of 1000 horse-power they would be able to retail liquid air at a profit at 1d. a gallon. If this could be done there would be no need to buy ice in summer. A simple machine, in which the liquid air expanded into its original vaporous state, would quickly turn water into ice, and keep all the provisions in a large pantry from becoming the least tainted. Meat, fish, butter, eggs, and fruit could be preserved fresh and wholesome and palatable for a long time; and there would be no necessity for using chemical preservatives in milk and cream, and jams and other articles of food. It would also be possible to have refrigerator stoves for keeping living-rooms at a temperate atmosphere during the hottest heat-wave. Dr. Graham A. Bell, the inventor of the telephone, recently returned from a tour in India with an idea for a cold stove for use in the tropics.

A first-rate refrigerator has been known to keep meat in a large cold-storage room free from the least taint of decay for twelve months. There are now in the great markets, and by the landing-wharves of London, many large buildings in which snow is falling all the year round. It is a strange experience to enter one of these places on some scorching summer day, and see the men working in heavy winter clothing, and slipping at times on the snow beneath their feet.

In the more modern structures, advantage is taken of the fact that cold air is heavier than ordinary air. It can be carried about in a pail. It always sinks

to the bottom of the room, and expensive leakages occur whenever a door or window is open. So a modern cold storage does not have any doors or windows—at least, none that is intended to be opened. It is an immense well of freezing air, lined with pipes through which the brine or gas from a great refrigerator passes, absorbing the heat as it flows. The refrigerator is continually pumping out the heat that enters the room from a topmost storey. It is on the top storey that the work of taking in provisions and letting them down into the well of cold air is performed. Nelson's cold storage wharf at Lambeth is a well-known example of the cold-air well system.

The carcases are brought alongside by river barges, and raised to the top floor by an ingenious endless chain, on the moving rungs of which the sheep are placed. From the top floor, the sheep are dropped into the various chambers, in which they are to be stored.

Still more ingenious are certain lifts used in the West Smithfield Store. When the attendant is informed into what chambers the various loads are to go, he moves certain levers and starts the lift, which then works automatically. When the place is reached at which the load is to be discharged, there comes into play an automatic cut-off that works in connection with the levers. So the lift stops and discharges the meat on to a table, and there the carcases fall away by gravitation and pass along chutes directly into the chamber for which they are intended. So, from the time that the meat is placed upon the lift, it only requires to be directed into its proper chute from the receiving table, and there is no need for it to be lifted till it reaches the room in which it has to be stored. All this not only makes for rapidity of transport but for cleanliness.

A good many people are still prejudiced against meat that has been kept in cold storage. But they eat and enjoy a good deal of it notwithstanding. The fact is that, if well-grown foreign meat is properly handled, it is as pleasant to the palate and easy of digestion, if not as good, as fresh-killed and well-hung English meat. The prejudice against it arose from the fact that at the beginning of the cold-storage industry there were some complete failures and many mistakes. To freeze meat properly, three processes are necessary. The fresh meat should be first hung in a chill-room at a temperature of 32 deg. F. While the room is being filled with fresh warm meat, the refrigerator should be stopped until the temperature rises another eight degrees, but the next morning the first degree of coldness should again prevail.

THE MACHINE THAT SAFEGUARDS THE CHILD'S FOOD — A REFRIGERATING INSTALLATION AT A DAIRY

the meat must then be removed to the freezer. Here a temperature of nine or more degrees is maintained, and the meat is left in it for two to four days. By this time it is frozen throughout, and in that condition it is transferred to the cold-storage-room, and kept at from 12 to 15 deg. F., a temperature which is low enough to keep meat in a frozen condition. Poultry and fish are treated in a similar way.

All frozen meat undergoes certain changes. The water which composes more than one half of the muscle substances is first lowered, and then expanded, by the cold. In its expansion it filters through the membrane of the muscle cells, and fills the interstices between the layers of cells. And there it freezes when the meat is placed in the freezing-room, with the result that crystals of ice fill out the interstices and squeeze the cells out of shape. In this condition the meat may be transported for thousands of miles from south to north, and through the burning tropic zone, without any harm befalling it, for all the ordinary processes of decay and decomposition are arrested. It is true that the germs are often alive and present, but they are quiescent. They are hibernating, as it were, leaving the carcase exactly in the condition in which it was when it was hung in the freezing-room.

PLACING FROZEN CARCASES IN COLD STORAGE

It is practically impossible to kill the germs by any practical method of producing cold. They have been exposed to the temperature of liquid air, and yet thawed out alive. But it is sufficient that they cannot, in a perfect cold storage, do in several months the damage that they could do in a single day on meat kept at an ordinary temperature. For all practical purposes their powers of evil are frozen into harmlessness by the expanding gas from the refrigerator.

The real source of trouble in frozen meat and fish and poultry is the ice that is formed in the carcases when they are put in the freezing-room. And the problem is to reduce this ice to its original watery condition, and make it return through the membranes of the muscle cells. This is now done by carrying on the thawing process in a slow manner. The crystals of ice then gradually melt into water, and this water filters back into the cells, and the cells resume much of their normal shape, so that the meat looks and tastes like fresh meat. If, however, the meat is thawed rapidly, considerable juice will ooze out, and the cells will never return to their normal condition. If, when the meat is slowly and carefully thawed, all the water of the muscle cells filters back, only a microscopic examination of the cells can show if they have been pressed by the ice crystals. It was by scientific methods of examination of this sort that the members of the Commission appointed by the Government discovered that a very considerable quantity of meat sold by first-class butchers in the West End of London as fresh and home-grown produce, and looking and tasting like it, was really foreign frozen meat that had been carefully and slowly thawed. Recent investigators into the problems of cold storage have come to the surprising conclusion that in a general way there is no appreciable difference in chemical composition between fresh meat and meat kept frozen for periods longer than two years. In regard to poultry, it is stated that the changes in chickens in twenty-four hours on a warm summer day are greater than those that take place during twelve months' cold storage at 10 deg. F. In short, cold storage has no deteriorating effect on the condition of meats, poultry, and fish for a period long enough to bridge over the time from one season of abundance to another. For every food substance there is a period of plenty, when prices are low to the consumer and profits large to the producer. This period of plenty usually covers but a

fraction of the year, and is definitely related to passing conditions of the weather and properties of the soil. During the remainder of the year food is comparatively scarce, and naturally high-priced. It can only be cheapened and brought within the reach of all by refrigerating processes used in the transport and storage of fresh provisions.

So every large increase in the use of modern methods of refrigeration tends to maintain a constant supply of food for the entire population. Even luxuries of the table that well-to-do people could not regularly afford a few years ago are becoming part of the daily diet of the working classes. The banana trade of the West Indies and the apple trade of Australia are both founded on an experiment with a Haslam refrigerator adapted for steamships about a quarter of a century ago. Besides this, there is now quite a large trade in Canadian apples; and one in soft fruits, such as pears, peaches, and grapes, has also been established. In 1908 there were forty-six steamers sailing for Montreal and Quebec with a cold-storage capacity of over a million cubic feet; and nineteen steamers with an air-cooled capacity of nearly the same area. Adding together all the sailings during the year, the total space of cold storage and cooled air was considerably over nine million cubic feet. As is well known, a good deal of this space, that has now largely increased, is used for the transport of Canadian butter and cheese; and the same provisions are also carried in huge quantities from Australia to our country by the refrigerating process. Dairy produce from Siberia is also being forwarded in refrigerating-cars across Asia and Europe, and transhipped into marine cold storage for the British market.

THE HOAR-FROST THAT COLLECTS ON THE PIPES OF A COLD-STORAGE DÉPÔT

Some day Canada and Siberia may be supplying us with cold-storage milk, though the cost of transport would be heavy. Yet milk from the Baltic has been sent to us since 1893; and thousands of gallons of cream are frozen and shipped from Gothenburg to London, to be used in butter-making. And all this can be done at a profit, the milk especially being 25 per cent. cheaper than English milk.

Practically the whole of the dairy industries are being revolutionised by the modern refrigerator. The cooling of town

milk, the cooling of separated cream, the cooling of water to wash butter, the cooling of butter stores and cheese stores and egg stores, are all best done with refrigerating machinery. In the successful manufacture of butter in hot weather, mechanical or ice refrigeration is essential. And pasteurised milk is now largely made by keeping it at a high temperature for twenty to thirty minutes, and then cooling it rapidly. By this means the flavour is preserved, and the milk will keep sweet for days. And, what is of more importance, the deadly disease germs, which spread from cattle to human beings through the use of fresh milk, are destroyed.

Another advance in healthfulness effected by the modern refrigerator is found in the new methods of ice-making. Artificial ice, when made by the latest methods, is much purer than natural ice. For the water is first distilled by boiling, and also freed from air, before it is subjected to intense cold. Yet the process is economical, by reason of the fact that the exhaust steam from an engine can be filtered and then distilled and used in making ice. There are various systems of ice-making, but they are mostly worked on the principle of keeping the freezing water agitated, so as to allow the prisoned air to escape, instead of remaining and clouding the ice.

THE COLDEST SPOT IN CALCUTTA—THE ICE FACTORY

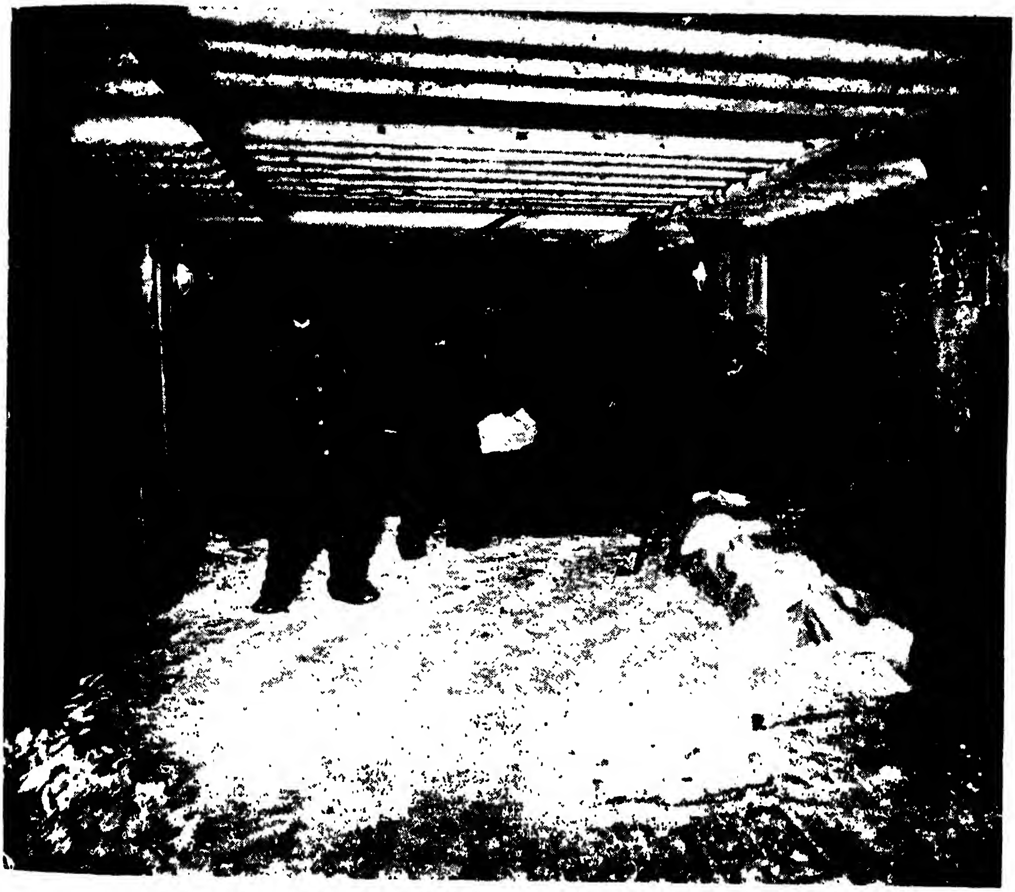
The principal feature of an ice-factory is the tank-room. Connected with this is the ice-store, the loading platforms, and, at a distance, the boiler-room and the machine-room. The artificial cold is produced by the same methods used in ordinary cold storage. In one method, brine is passed over the refrigerating coils, and then led into the ice-tank; in the other, the expanding ammonia-gas runs through pipes in the tank and directly freezes the water. Over the tank is a hoist or crane that lifts up the great blocks of ice and carries them away to a platform. But in some cases the ice-blocks are sent down an inclined plane or runway, from which they slide into the ice-store.

Then there are sometimes endless chains, provided with hooks that grab the blocks of ice, and raise them from one floor of the factory to another; and circular saws are used that cut the ice into small blocks, which then travel automatically down a conveying belt. Another machine receives great blocks of ice by means of a hopper, and then breaks it up into small pieces under a pair of rollers that grip the ice-slab with their steel points. It is in this way that small ice is made for fishmongers, hotel and restaurant keepers, and for packing newly caught fish on trawlers. This small ice is also used in keeping fish for railway transport; and in larger sizes it is employed on many refrigerating-cars. Here, however, the small liquid-air refrigerator is likely to come into universal use as soon as liquid air can be made more cheaply. Its chilling power, as it expands back into the gaseous state, has already been put to good use in some refrigerating-cars in America.

Like many other important inventions, the modern refrigerator can be employed in ways that its first inventors never dreamed of. For instance, refrigerating machinery is now becoming an essential part of a blast-furnace. It is strange to find a mass of snow close to the white and blinding heat of one of these huge furnaces. But the machine that produces this snow saves about 15 per cent. in the consumption of coke, and increases the production of iron by 10 per cent. It does this by taking all the moisture out of the air-blast, and drawing it off, partly in the form of dew and partly in the form of snow. So the air passes in a very dry condition into the furnace. Powerful refrigerators are also necessary in candle and paraffin oil works. Out of the paraffin oil they freeze the valuable solid paraffin that is largely used in candle-making. This process is so important that the development of the paraffin industry dates from the time when a refrigerating machine was used in the refining process.

Until artificial refrigeration was first used in 1882 in cooling chocolate, the manufacture of this article of food had to be suspended in the hot weather. The chief chocolate manufacturers now use artificial cold on a large scale, for it makes for more rapid production and fewer moulds and much less waste. The modern brewing industry has been entirely built up on the refrigerating-machine, which enables operations to be carried on on a larger scale and with more accuracy than was possible under natural conditions. In tea-factories and soda-water works, refrigeration is also largely used; and in sugar factories and refineries concentrated juices are obtained by freezing and removing the superfluous water. In indiarubber works, artificial cold is necessary in cheapening the cost of manufacture, and permitting the material to be worked up in a better manner than was formerly possible. In the manufacture of photographic accessories, gelatine and other substances are now usually cooled by refrigerating machinery; and the manufacture of dynamite has been made much safer by the same means.

The refrigerator has also been an important instrument of progress in many other industries, in which it would be impracticable to carry out certain processes in the hot summer months, without some artificial means of cooling the material. Even in great constructive engineering works, such as the driving of tunnels and the sinking of shafts, the refrigerating-machine has given man new power in his struggle against adverse natural conditions. A good many coal-mines in France have been made possible for working entirely by means of a refrigerator. For in all cases where a water-bearing strata is reached, through which it seems impossible to build a shaft or a tunnel, refrigerating-pipes are inserted, and the chilling gas is circulated through the pipes, until the ground is frozen solid. Then a water-tight shaft or tunnel is built through the hard, frozen earth.



CLEARING THE FROST FROM THE PIPES IN A COLD-STORAGE ROOM

WOMAN'S WARMTH FROM MOUNTAIN COLD

One of the most desired of the furs that provide woman with warmth and ornament is the chinchilla, the grey and black coating of a small animal that lives high upon the cold Andes of Chile, Bolivia, Peru, and Ecuador. It is eagerly hunted by the Indians of that lofty region. There the dart and blowpipe remain in use, because they kill with less damage to the fur than other forms of shooting.

THE FUR & FEATHERS TRADE

The Astonishing Modern Developments in the Most Ancient of All Industries

THE CRIMES OF THE PLUMAGE HUNTERS

FUR-HUNTING and fur-trading are the oldest industry in the world. The primitive man of the Old Stone Age, who killed a beast with his flint axe and made its skin into a garment for his wife in winter, was the first of the manufacturers of the world. And it is women still who chiefly love the warmth and softness of clothes made from the furry pelts of animals. It is for them that thousands of trappers work in the height of winter amid the snow and ice of the Arctic and sub-Arctic regions of Northern America and Northern Asia. What gives a special romance to the fur industry is the fact that it directly led adventurous pathfinders to open up one half of the world. It was the little sable that lured the Cossack from the Ural Mountains to the Pacific Ocean, and so led to the foundation of the mighty Asiatic empire of Russia. It was the beaver that drew Frenchmen and Dutchmen and Englishmen to Northern America, and inspired them to discover the St. Lawrence and the Mississippi and the Rockies.

The famous Hudson's Bay Company was founded to supply England with beaver skins; its vast acquisition of millions of miles of territory was only a side-activity. Its main object was procuring the fur of the little brown beaver for making felt hats. The part that the love of gold played in building up the Empires of Spain and Portugal was supplied by the pursuit of the grey sable and brown beaver in the empire-building of the Russian and the Anglo-Saxon races. The figure of the beaver is still a conspicuous device on the escutcheon of the city of New York, where in old days beaver skins were used instead of gold and silver for currency. Many of the chief towns of the United States and Canada have developed from small fur-trading stations. St. Louis and Chicago were, like Winnipeg in our own time, tiny outposts of civilisation, formed by the trapper and the trader as they pushed through forest and prairie in pursuit of new supplies of pelts. The same process went on in the Asiatic dominions of Russia, until the Russian and the Anglo-Saxon almost ringed the world in their quest for fur, and met in Alaska. It was only by a mere chance that the Russian did not acquire all the Pacific coast as far as California.

So the well-known fact that the finest fur-bearing animals are found in the Northern hemisphere and towards the cold zone has had a very happy effect on the expansion of the two now most populous races of European origin. For the sable and the beaver have led them into vast and fertile temperate regions where they were best fitted to multiply. Unlike the Spaniards and the Portuguese, they had not to fight against deadly tropical diseases, which enabled the more resistant natives to outbreed them. On the contrary, the Anglo-Saxon in particular survived against the new diseases he introduced, such as consumption and measles, which killed off his savage neighbours, simply by reason of the fact that he settled in a bracing climate that suited his constitution. Thus the healthy occupation of fur-hunting and fur-trading enabled him to establish a healthy empire. Both he and the Russians chose a harder and more rigorous scene of adventure than did the gold-seekers from Spain and Portugal; and they are now entering fully into the enjoyment of the fruits of centuries of hard toil and character-testing endurance.

And the extraordinary thing is that, in spite of the immense regions that the Russian and Canadian have recently brought into cultivation, there seems to be no danger of their exhausting the principal sources of fur which they possess. Yet

through their efforts the growth of the fur trade has been enormous. The immense increase in the numbers and wealth of the white races has brought about an extraordinary development of the fur industry. For the civilised races of the temperate regions are in practically the same position as the cave-men in winter. When the weather is warm their clothes of cotton and wool and silk are sufficient for comfort and health. But when they need garments to protect them from the biting east wind they must still use the skins of furry animals. The leathery-like pelt keeps out the storm, and the fur wards off the cold. The result is that furs are as much a necessity today as they were in prehistoric times; and owing to the huge populations of the modern civilised world, the oldest of all industries is still of great importance.

SEAL-HUNTERS IN THE FROZEN NORTH

Few persons have any idea of the enormous volume and value of the fur trade. But every keen observer who strolls in winter along the shopping streets of our great cities must be struck with the extent to which furs are worn by women, and with the number of fur shops and fur departments in drapery establishments. The wonder is, then, where the supplies come from, and how it is that a clean sweep has not long been made of all the chief furred animals. As a matter of fact, the supply is easily kept up, with the exception of the skins of sea-otters and fur-seals, which have become remarkably rare, and beavers, which have been greatly diminished. With these exceptions, among which must be included certain African monkeys, it does not appear that any of the valuable fur-bearing animals are in danger of extinction.

SEAL-HUNTERS HAULING SKINS TO THEIR SHIP

Indeed, we have little conception of the abundance of such animals in the cold, remote, and practically uninhabitable parts of Northern Canada and Northern Asia. Regions of continental expanse, where man can never hope to raise crops, will always be available for supplying him with the best of winter clothing. A good deal of the cold and barren wilderness is really becoming converted into a kind of vast wild farm for breeding fur-bearing animals. In the Hudson's Bay territory, for example, great care is now taken not to exhaust a district. When it appears to be growing thinned, arrangements are made to leave the animals undisturbed for two or three years. So no trapper camps there in the depths of winter, and lays his wires and then watches and waits in the freezing air for a trapped animal. Moreover, all the creatures are free from attack by the hunter eight months out of twelve. For in the breeding season and in the summer-time their skins are valueless. The fur is scanty and in bad condition, so it is absolutely useless for making into a garment. No trader will buy it at any price, or even take it as a gift. Only in the height of winter, when the animals have grown their winter coats to perfection, is it worth while for the poorest Red Indian or half-breed trapper to set his wires.

The consequence is that the trapping of the best fur-bearing animals is a toilsome and difficult matter that calls for high powers

of endurance, as well as a marvellous knowledge of the ways of the animals. A gun cannot be used, for the shots would injure the skin; neither can poison, for its effect is still worse; the animal cannot be left for any time in the trap, for this, too, seriously diminishes the value of its fur. The trapper has therefore to spend most of his time going in his snowshoes from trap to trap, taking the animals out as soon as possible after they have been caught. It is bitter, trying work; and one of the chief causes in the rise in the cost of furs is that both the Red Indian and the half-breed trappers now require to be adequately paid for their strange, lonely, and perilous toil. The hunters are no longer ignorant savages, ready to sell the skins, which they have secured by long watches in the snow, for beads or blankets or tobacco, representing but a ridiculously small part of the true value. They no longer barter on the principle that a musket is worth as many skins as will, when piled close, equal the height of the weapon from top to barrel. No enormously long-barrelled firearm is now manufactured for the North American market. An extended knowledge of the principles of modern commerce have regulated prices to definite market values, even between the trapper and the first consignee. So there are no fancy bargain prices for furs, except under very exceptional circumstances. For this reason, any fine fur that is offered much under the market price in a shop may be regarded as merely a clever imitation of the real thing. This is the only way in which finished articles can be offered for sale at a price which a trapper would indignantly refuse for the rough, undressed skins.

THE WIGWAM OF RED INDIAN TRAPPERS

Of course, when a district is becoming exhausted, the work of the trapper grows harder. So he is ready, at a suggestion from the agent for the fur company for whom he works, to move on to a fresh camp. Thus there are several natural causes that prevent the great fur countries from diminishing their general sources of supplies. And since women have become the chief wearers of fur, the ingenious merchants who provide for them have discovered another means of protecting any fur-bearing animal that is threatened with extinction. We do not believe in the common explanation given in regard to the changing fashions in furs. It is said that fashion creates a trade. We are told that some woman takes a fancy to buy something entirely different from the fur that everybody else is wearing. So she has a chinchilla stole made for her, or a mink coat. Then somebody sees it, and orders one like it. So this special fur becomes the fashion, and prices go up. Word is sent to the trappers. They pursue that fur the most because it pays the best. So, while the fashion is in, the other fur-bearing animals get a rest. For instance, mink was not wanted a few years ago, so mink became plentiful. Then mink became a passion, and there were quite enough of the little animals to supply the immense demand, until first the chinchilla and then the grey squirrel became the fashionable fur.

A DEPÔT OF AN ENGLISH TRADING COMPANY

Such is the orthodox explanation. But

we are of opinion that women now have their fashions given to them. The feminine desire for incessant change is transformed by the fur merchant into an instrument for protecting the animals that are growing rare. Buying in open market with his fellows, he takes some fur that is cheap and abundant, simply because it is not fashionable, and he blandly and subtly engineers a fashion in it. Exactly how he does it, we cannot tell, for there are many ways of promoting a new fashion for women. An aristocratic customer of taste may be induced to take up a beautiful, neglected fur, and thus distinguish herself from her dearest friends. In France, the gift of a new kind of fur to some well-known actress, who can give distinction to anything she wears, will sometimes create a new fashion. And many French noble ladies are so deeply in debt to their rich tradesmen that they are ready to serve as their models in society when a new fashion has been decided on. Just as ordinary new modes in dress are engineered by dressmakers with a view to forcing women to discard their clothes before they are worn out, so fur merchants more legitimately employ similar means in order to prevent the strange passion that women have to dress like one another from bringing about the extinction of the particular fur-bearing animal in whose skin they all desire to array themselves. Naturally, the continually rising cost of a fashionable fur helps the fur-maker in his beneficent design, but it is by starting a new fashion that he compels women to help him in his work of protecting some over-hunted creature.

SETTING SPRING TRAPS FOR THE MUSKRAT

The only two fur animals of high importance that have suffered are the sea-otter and the fur-seal. The sea-otter is almost unknown in our country, in spite of the fact that a good many of the skins used to pass through London. Its dense and silky fur was exceedingly fine, and had a shimmering gloss of silver over the brown under-fur. It was the royal fur of China, and only persons of high rank were entitled to wear it. A similar sumptuary restriction obtained in regard to the use of sea-otter fur in Russia. Some time ago it was not unusual for a skin to fetch £500 in China. Now the price would be much higher, for the sea-otter, that used to haunt the shores of the Northern Pacific from the Behring Sea to Mexico, is almost extinct. Only now and then, in a fierce tempest, does some Aleutian islander row out at the risk of his life, and find some storm-driven otter battling for life in the thundering surf. Seven hundred thousand of them have been killed for the Chinese and Russian market in the last two hundred years. But the killing has been done in so brutal and indiscriminate a manner that the most valuable and lovely of all aquatic fur-bearing animals is almost as extinct as the dodo.

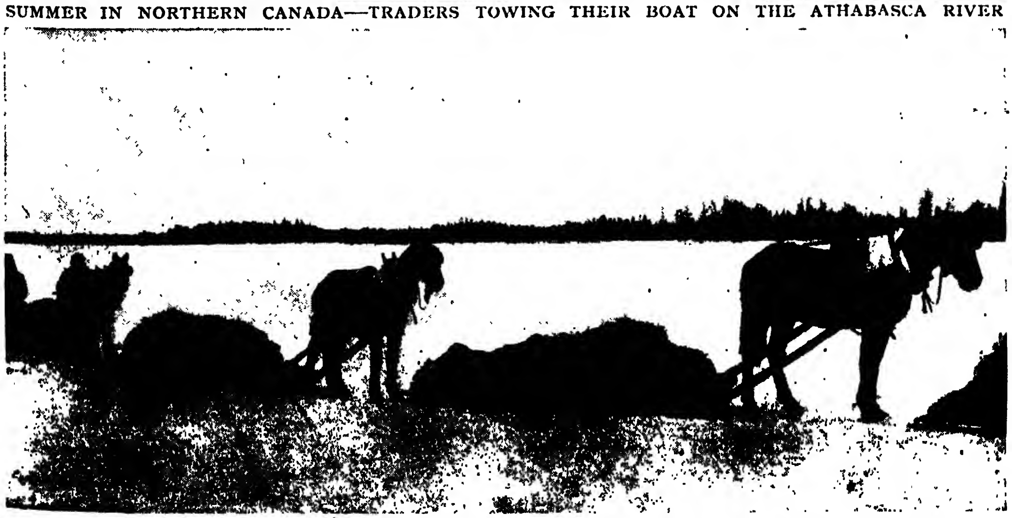
The sealskin so prized by Englishwomen is not as beautiful as sea-otter fur, but it was recently in danger of perishing from the earth. The fur-seal rookeries in the South Shetlands have been utterly destroyed, and now the last refuge of the fur-seal on Commander Islands, in Russian territory, and Pribilof Isles, in Alaska, has been depleted. This was done mainly by Japanese seal-poachers. They used to wait for a fog, and then run in their boats and kill every seal they came within reach of. Great cruelty and great wastefulness were the distinguishing feature of their illegal operations.

In an ordinary way a seal rookery is inexhaustible, for the sealers only take the young bachelor seals that would be killed or driven away by the bull seals, who fight every season very savagely for their family group of females. So long as the bull and his wives are untouched, and only the bachelor seals stunned and taken away, the rookery will flourish. But the poachers slew females with their young, and the fur-

WINTER AND SUMMER IN THE FUR COUNTRY

ESQUIMAUX DOG-TEAMS DRAGGING SLEDGE-LOADS OF FURS TO CENTRAL DÉPÔTS

SUMMER IN NORTHERN CANADA—TRADERS TOWING THEIR BOAT ON THE ATHABASCA RIVER



SLEIGH-LOADS OF STORES ON THEIR WAY TO THE OUTLYING COLLECTING STATIONS

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seal was disappearing from the world when the United States Government began what promises to be a successful attempt to preserve it. The Canadians and the Japanese are being paid a fairly large sum of money to desist from killing the fur-seal, and the two remaining rookeries in American and Russian territory are being guarded against all aggression for some years. Not a single seal is being killed, and it is hoped that the few survivors of the rookeries will increase in number.

In regard to some other very rare and very valuable fur-bearing animals, private enterprise seems to be doing as good a work of preservation as Government action. Messrs. Revillon Frères, of Paris and London, have turned a rocky island off the bleak Labrador coast into a kind of farm for breeding silver foxes. The same firm also have at Bokhara a farm for raising the Persian lambs that yield a fine and beautifully curled fur. In their silver-fox farm the animals run wild. It is found that when they are kept tame their skins lose all their precious qualities. It is the same with all the finest wild, furred creatures. The quality of their fur is directly due to the rigorous conditions of their savage life. When these conditions are mitigated, the animals become practically worthless. But as a first-rate silver fox is worth £500, it is profitable to take the trouble to provide him with the free range of Arctic island, and arrange that he gets a considerable amount of exercise in obtaining his food. Fur-farming of this sort, therefore, can only be carried on on a large scale in some bleak region, where the winter is very severe, and it is difficult to breed the creatures that provide the fox with exercise and food. For they, too, must run wild, in order that he shall be put to considerable exertion in hunting them.

A RED INDIAN CAPTURING BEAVERS WITH A NOOSE TRAP

The French firm have also had great difficulty in getting the foxes to breed true. All that they want is the lithe, beautiful, silvery-white creature of the Northern snows; but though they mate the best specimens together, there is often a number of ordinarily coloured cubs in the litter. Yet the enterprise has seemed prosperous enough for a blue-fox farm to be started on one of the Aleutian Islands, off Alaska, which is, we fancy, conducted by the same enterprising French firm of furriers. So perhaps in course of time all the sizeable islands in the Arctic regions will become valuable properties, on which the rarest of land furs are produced by a system of wild farming.

But in the United States of America it is found that fur farms do not pay. Fur comes to its greatest excellence only when animals have a wide range and live in their natural state. Above all things, they must not be protected against cold weather, for it is in the ice and snow of winter, when they often have to travel far to get food, that their hair grows thick and warm to enable them to bear the extreme coldness. It is simply because it has to stand a colder climate that the Himalayan tiger grows a skin worth a hundred pounds, while his more comfortable kinsman, the Bengal tiger, in the warm jungle lands, has a pelt that is only worth about six pounds.

Yet if an Arctic island were available with the food that the Russian sable needs, it would be a profitable property for a fur-

farmer. For now that the sea-otter is gone, the Russian sable that led the Cossacks over Asia is the most valuable of fur-bearing animals. It is an animal about the same size as the marten; in fact, it is a kind of Asiatic weasel, and so it is naturally hard to trap. Small as the fur is, a fine one will sometimes fetch £70; and it cost a Tsar of Russia £3500 to get a perfect sable robe. At the present time £1000 is scarcely an extraordinary price for a fine sable lining of a large size. The darkest and finest skins come from the Gakutsky district of Siberia, but the little animal is also found in Northern China and Kamscatchka. More abundant is the Canadian sable, which is known as the marten. Yet these are now so esteemed that a trapper receives from £1 to £7 a pelt; and when it is borne in mind that a sable skin is not much longer than a man's finger, it will be seen that a fur garment made of fine and well-matched skins cannot be very cheap.

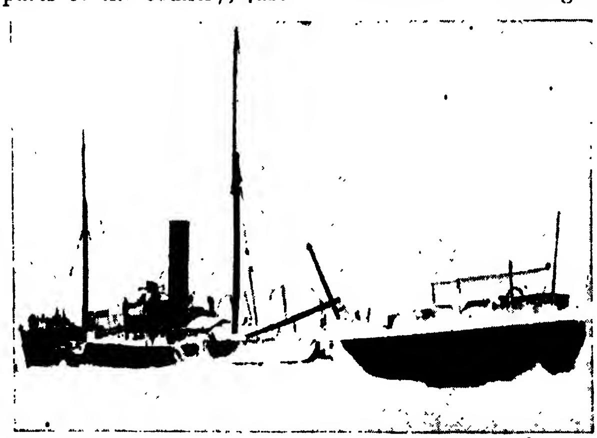
The mink is another of the weasel tribe that sometimes approaches the Russian sable in the quality of its fur. Its coat is of a reddish-brown, but sometimes it has a slatey or a smoky tinge of a fine colour. The mink abounds in Canada, and half a million skins are sometimes sold at the annual market in London. Many other fur-coated animals of the weasel tribe are used in commerce. For ages the Armenian white weasel was famous as the ermine. And British white weasels used to be made into the famous fur; and so did a similar animal in Brittany. As is well known, the black spots in ermine are manufactured by sewing

RED INDIANS SELLING FURS AT A HUDSON'S BAY COMPANY STATION IN NORTHERN CANADA

the dark tails of the animal into the pelt, or by intersetting it with the black paws of astrachan lamb. The weasel must be snared in winter, as in summer the upper part of its body is of a pale, tawny-brown colour. Stoats, with their white winter coats, are sometimes used in making ermine, which has always seemed to us a rather dear fur, having regard to its humble and abundant source. No doubt it owes its prestige to the fact that it is the fur of English royalty, and part of the State dress of our nobility and judges.

A SLEDGE-LOAD OF SKINS ON THE WAY TO A DÉPÔT

Another fur of the weasel family is that of the American skunk, which is now imported in large quantities. Its coat is soft and very thick, and the under parts are black; while a white line broadens along the sides and continues to the tail, leaving an egg-shaped black space upon the back. But the American fur in greatest abundance is obtained from the muskrat, or musquash. This rat is the plague of the American farmer in some parts of the country, just as our wild rabbit is. Far from decreasing in number, when the land is put under cultivation it overruns the country, doing especial damage to the banks of rivers. It is a water-rat, somewhat like our vole in its habits. The best of these rat furs are black in colour, but the commoner, paler coats are now largely dyed in imitation of the furs of rarer animals.



A FUR-TRADING STEAMER ICE-BOUND IN HUDSON'S BAY

The muskrat of America, the grey squirrel of Asia, and the rabbit of Europe form the largest and the cheapest source of furs. The best grey squirrels come from Siberia, and they are distinguished by the lustre and beautiful tone of the furs. Much skill is required in matching the skins; the back of the fur is the most valuable portion, and the white and light grey under parts are used for cheaper linings. Over three million squirrels of the Asiatic kind are killed every year for their furs, but the little animal is so abundant, and it ranges over so wide a region, that there is little danger of its disappearance. A more beautiful grey fur — indeed, the softest and most delicate in existence—is yielded by a little South American rodent, the chinchilla. But its skin is very thin and tender, so the fur is not very durable.

The commonest South American fur is that of the coypu, or nutria. The fur resembles that of a small beaver, and, as in the case of the beaver, the coat has to be dehaired in dressing. That is to say, the long over-hairs have to be plucked out, leaving the soft, thick, under fur for use. In addition to dehairing these furs, they are sometimes silvered in the same manner as a beaver-skin. This is an expensive process, for it consists in sewing silver hairs very skilfully into the skin so as to produce a charming silvery effect above the soft brown natural colour. Another way of producing an artificial beauty in common furs is to top them. That is to say, the top part of the fur is dyed to some harmonious tint that produces a pleasing contrast to the natural colour of the under part of the coat. It is, in fact, the dyer who gives a transient beauty to all the common furs, changing them from an

The upper picture shows the ingenious method whereby the wily Esquimaux traps the almost extinct sea-otter. Nets are sunk through holes cut in the ice, and are suspended from a bell, which announces a capture to the waiting hunter. In the lower picture a travelling purchaser of skins is bargaining for a silver fox, which, when prepared for use, may be sold for hundreds of pounds.

ordinary-looking thing into something rich and strange.

French and Belgian dressers and dyers, indeed, boast that so long as a rabbit lives they can manufacture a passable imitation of any known fur. Probably a hundred million rabbits' coats pass through the dyers' hands every year, together with two or three millions of hare-skins. These, with the thirty million muskrats' coats from America, provide all the cheap variety of furs worn under different names every season. The white rabbit masquerades in death as an ermine or chinchilla; the ordinary rabbit goes into a dye-bath and emerges in a multitude of forms. In a comparatively honest shape, he calls himself French sable and electric seal. But sometimes he brazenly tries to pass himself off, when pulled and dyed, as a fur-seal or a rare kind of sable. Inland seal and coast seal are also rabbits in disguise.

AN ESQUIMAUX FLESHING A SKIN

So ingenious and widespread is the art of imitation furs that some pages would be needed to give full particulars. Under the Merchandise Marks Act of 1887, all these attempts at deception are illegal, and the London Chamber of Commerce has issued warnings to British furriers of the danger of fraud in furs. Our women, however, have a curious passion for fine names for inferior articles. Not only in furs, but in dress materials and dress ornaments, they are always ready to pay a higher price for a finely named imitation than for an imitation under its proper description. They like to deceive themselves, and they are willing to pay for their love of pretentiousness So in the fur trade, and in the drapery and millinery trades, a kind of open fraud in description is likely to continue

PRESSING SKINS FOR EXPORT BY PRIMITIVE METHODS IN NORTHERN CANADA

The cheap muskrat, pulled and dyed, is sold as seal or beaver; and the South American nutria also becomes a beaver. Sealskins are also strangely obtained from ordinary otters. Little white lambs are changed into the white foxes of the Northern snows; and the white hares that these foxes hunted also become foxes when they die. The Australian opossum migrates to London, where, by the magic wand of the dyer, it is changed into the chinchilla of Peru. In the same way the wallaby of the Antipodes becomes a lynx from Finland, while the timber-wolf of Canada is changed into a Kamtscatchka fox. The marmots of Mongolia suffer a change when they die, and become mink or sable. It will be remembered that some Chinese poachers of these marmots were so ignorantly greedy for gain that they collected the skins of animals that had died of the plague. The result was that the plague broke out in China, and spread into Russia; and a year ago it seemed that the whole of Europe was in danger from the Oriental epidemic. This would never have occurred if the Chinese had not interfered in a matter about which they knew nothing. The Mongolian marmots always suffer more or less from plague, but the real trappers are careful, for their own sakes, never to touch, much less skin, a diseased animal. Still, the event goes to show that sable furs made from marmots are not the healthiest form of garments.

Among other imitation furs are the sables made from polecats, and the bear-skins and leopard-skins manufactured from the dyed pelts of goats. The American opossum is sold as Russian marten, and the coons of Minnesota become the bears of Alaska. A black dye changes the large hares of Europe into Baltic lynxes, and the skunk is transformed into a sable. Even dogs and cats and foxes and monkeys sometimes undergo strange adventures in the hands of the dyers and dressers of the Continent. The cats in the black-cat farms of Holland are also liable to come under the wands of the magician, and have the quality of their coats changed in a way that makes them more valuable. In short, all the common furs of the world are now sheared or pulled and dressed and dyed in various way and sold under high-sounding names that disguise their real nature.

Rabbit fur is by far the most used in imitation processes, and it is the least durable. But it is also employed in large quantities and legitimate ways for making felt hats. Formerly beaver fur was chiefly used in hat-making. The fine fur was cut off the skin and worked on the nap of the hat and dyed, making a fine glossy felt. But when the silk top-hat came into fashion the use of beaver felt was discontinued. Then came the invention of the soft felt hat, and the rabbit was transformed into the leading character in an industry of great importance. After the long hairs have been removed from the skin, the fur is cut off by machinery, and sorted by being blown about with air. The fur is placed in small handfuls on a tray, from which it passes to the blower, which drives the fur on to a revolving copper disc. There the fur accumulates and mats into a thick covering, and this is removed and washed, and is then ready for making into soft felt hats. Even the skin of the rabbit is not wasted, for when the felt-makers have done with the pelts they are sold to manufacturers of gelatine Many gelatine jujubes are made from rabbits' skins.

In the dressing of furs for fur garments England and Germany are supreme. London is the greatest fur market in the world, and the business is in the hands of about half a dozen brokers. So well organised is the London market that furs from many remote foreign parts pass through before they return in a dressed and finished condition to the district from which they were first sent. The sales are usually over in March, and the fur merchants then hasten to Leipzig for the Easter fur sales there, and from Leipzig they go to Nijni Novgorod, in Russia, where the last great fur sale of the year takes place. The English buy sables, martens, chinchillas, foxes, otters, seals, lions, tigers, and leopards, for these are the pelts they excel in preparing. The Germans purchase squirrels, Persian and

SORTING FURS AT A BIG DEALER'S IN LONDON, THE FUR MARKET OF THE WORLD

Russian lambs, mink, muskrat, and skunk, for they are also unequalled in preparing these pelts.

The town of Weissenfels, in Saxony, lives entirely on the craft of fur dressing. The Germans have many secrets in dyeing and dressing, so we cannot pretend to give the processes. Sometimes the art lies in getting the oil out of a white pelt without tinging the fur yellow. This is important in dealing with ermine, white fox, and Polar bear skins. As in England, the furs are polished with butter, and they are deodorised by trampling them in mahogany sawdust. The drawback to the German method is that in large skins the felt is left rather thin, thus being more liable to damage. In the English dressing, the skin is somewhat less flexible, but more durable in wear. Usually the trapper cleans the skin of flesh, and dries it gradually in the air. In this state it comes to the dresser. He places it in an alkali bath; and when it has there grown soft it is stretched, and the moisture is worked out of it by means of a blunt tool. The pelt is then shaved by being pulled over a large fixed knife. Afterwards it is buttered, and put in a large tub of sawdust, where it is trodden by men. This further softens the leather, and frees it from odour; and when the dust is beaten out the dressing process is finished.


NATIVES SMOKING THE SKINS OF BIRDS OF PARADISE

Many skins are then partly dyed by dipping the ends of the hair with colour, leaving the under fur and pelt free from the dye. This often makes a useless skin into a marketable one. As we have already remarked, the dyer often transforms the common fur into a colourable imitation of some rare and costly pelt. But here again the processes are jealously guarded trade secrets, by means of which the industries are confined to one or two countries. In recent years the use of coal-tar dyes has provided the dyer with an abundance of materials for his curious art, enabling him to start new fashions in great variety without changing the source of his fur supply —which is generally a rabbit warren. And so long as most women only want a fairly warm fur, that will last in good condition for a winter or two, there seems to be no reason why the prolific coney should not, with the aid of the skilful dyer, provide them with all they need.

On the whole, the fur industry is conducted in as careful and humanitarian a way as the meat trade. A large number of the fur-bearing animals are what a gamekeeper or a farmer would call vermin. In cultivated regions they do much damage; and in the bleak wildernesses of the North they enable the hard-working trappers to live in a cheerless waste of snow and ice. Were it not for the fur industry the Red Indians of Canada would have been hard put to it to survive. They have done so mainly because of the kindly way in which the Hudson's Bay Company have managed them. The practical abolition of the liquor traffic for skins has saved the Canadian Red Indian, and enabled him to win the food and clothing required for himself and his family.

If only the feathers that women desire for the adornment of their persons were obtainable in the same way as their winter furs generally are, a stain would be removed from modern civilisation. Many of the loveliest of birds have been sacrificed to man's greed and woman's vanity.

The bird of paradise is disappearing from New Guinea, and the lyre bird from Australia. The handsome Jabiru stork, with its silky, ivory-coloured feathers, has been exterminated from most South American rivers, for the gratification of women. White heron feathers are yearly exported from Venezuela to the value of £30,000. And the same bird is being pursued everywhere in Cuba and Jamaica by the plumage-hunters, though Mr. Roosevelt stopped the wicked slaughter in Florida. But it goes on in China and Southern Asia, and the Japanese bird-poachers are ravaging the Pacific to supply

the European feather trade. Some years ago they attacked a bird reservation of the United States on Lisiansky Island. They fitted out a ship containing eighty-seven killers and skinners of birds, and collected the plumage of three hundred thousand birds on the preserved island. In addition to the shocking waste of beautiful life for the fantastic decoration of brainless women, these ravages entail a heavy economical loss.

For the sea-birds of the Pacific coast and islands are the producers of guano, the most valuable fertilising agent in the world. The ancient Incas of Peru made laws for the protection of the guano-forming birds, and ordered that they should never be killed, and that their nests and eggs should not be disturbed. By this means the Peruvians were able to maintain an inexhaustible supply of the fertiliser needed in their admirable agricultural system. But the guano deposits have now been ruined by bird-pirates, who dodge the warships of the United States and Great Britain, and pack their ships with the feathers of some of the most useful species of birds in existence. Japanese, Russians, Americans, and Canadians compete in this criminal work of slaughter.

PLUCKING PLUMES FROM THE OSTRICH IN SOUTH AFRICA

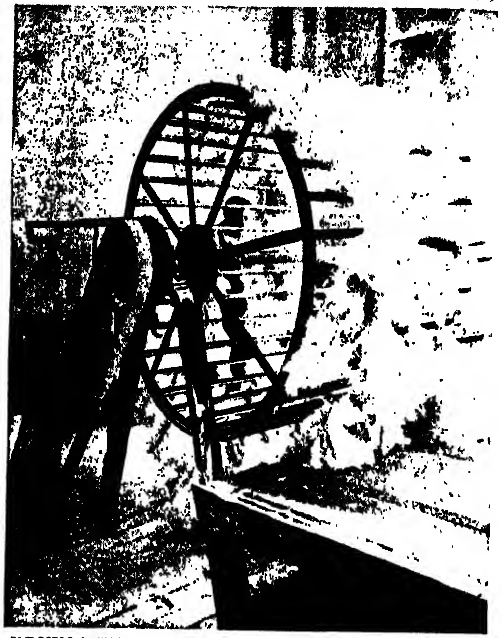
In Jamaica man is already beginning to pay a heavy price for the profit he has made out of feathers. For, now that the beautiful native birds are disappearing, ticks and other noxious parasites are increasing to such an extent that food-crops are often destroyed, and several kinds of cattle are overtaken by strange maladies and perish. The destruction of various plumage birds in the United States is also causing heavy loss to farmers and fruit-growers. The beautiful scarlet tanager, that is now disappearing, can kill 2100 moth catapillars in an hour; the yellow throat-warbler can eat 3500 plant parasites in a minute. So while 500,000 plumage birds are now yearly destroyed in the United States for the adornment of women's hats and garments, the increasing damage done by insects to the trees, vegetables, and fruit of the country now amounts to more than £20,000,000.

A more deplorable condition of affairs is being brought about by the plumage-hunters of Africa. It is now known that certain flies that spread some dreadful tropical maladies are the natural food of the guinea-fowl that Europeans are now wantonly destroying. And there is good reason to believe that the African heron and other plumage birds do much to keep down the flies and grubs that spread disease. So the plumage-hunters directly make their money, out of the tortures and death of hundreds of thousands of black men and white men, through the wholesale destruction of the birds that used to protect human beings from the carriers of dreadful tropical diseases. The extraordinary way in which the sleeping sickness has recently spread through vast regions of Africa may be partly due to new facilities of human communication, but the destruction of the birds that kept down the deadly insects is an important factor in the affair. A great African adminstrator recently exclaimed, with a certain savage justice, that a woman who wears in her hat the feathers of a useful bird ought to be put in prison, together with every merchant and plumage-hunter that ministers to her murderous vanity.

If the feather industry were conducted in a legitimate and humane manner, it would be chiefly confined to ostrich-farming, and to the dressing of the plumage of birds used for food. The poultry and game

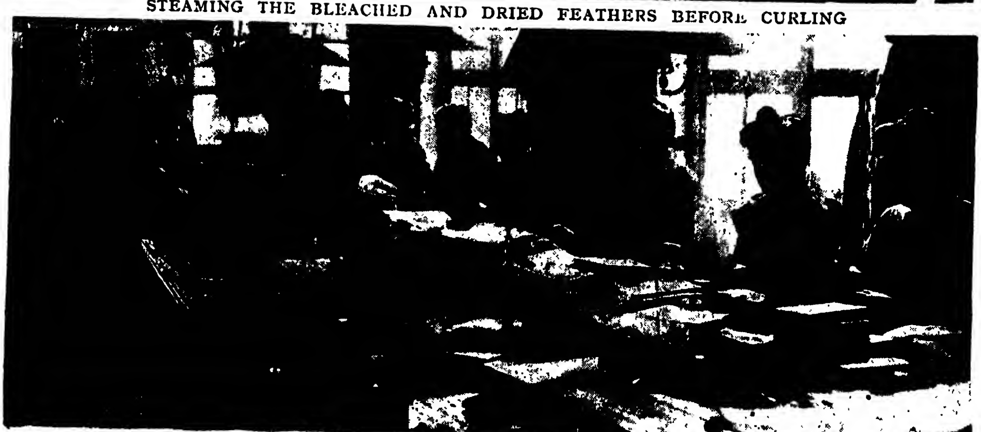
PREPARATION OF OSTRICH FEATHERS

WASHING OSTRICH FEATHERS BEFORE BLEACHING AND DYEING ON THEIR ARRIVAL FROM A FARM



DRYING THE BLEACHED OSTRICH FEATHERS BY BEATING THEM ON A REVOLVING WHEEL

STEAMING THE BLEACHED AND DRIED FEATHERS BEFORE CURLING



SORTING, SEWING TOGETHER, AND "LANCERING" OR KNOTTING TOGETHER THE BARBS

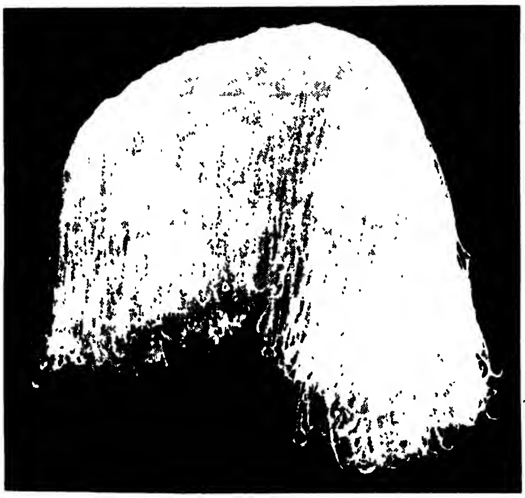
AS AN ADJUNCT TO THE BEAUTY OF WOMAN

CURLING THE BARBS OF OSTRICH PLUMES BY MEANS OF A BLUNT KNIFE

TWISTING AN OSTRICH-FEATHER BOA TO GIVE A FULL, RICH EFFECT

The photographs on these two pages are by courtesy of Messrs. D. W. Muller, agents for Messrs. Duplot & Co.

consumed in our country would provide material for a large industry. But at present we do little more than collect the feathers, on which the clever and skilful French plumage-dressers work. Our feathers go from Folkestone to France in order to be transformed into articles of adornment. The feathers are first freed from oil by washing in warm soapy water; or the oil is chemically removed by benzine. The feathers are then placed in a strong solution of hydrogen peroxide, to which a little ammonia is added. This bleaching fluid entirely destroys the natural colouring matter of the feathers; and as it does this without injuring the texture, its discovery has revolutionised the plumage industry. For it enables the manufacturer to produce artificially dyed feathers of infinitely varied tints from the cheapest and most abundant of natural supplies. In the best work the colours are put on by means of a spray worked by compressed air; and fine fancy effects in different hues are easily obtained by a workman with the feeling of an artist. When dyed, the feathers are dried in a rotating apparatus, and then the final process of curling the tips is carried out, by turning the feathers round and round over a gentle heat.



THE OSTRICH PLUME READY FOR WEAR

Though the French, by reason of their general artistic gifts, hold a commanding position in the art of plumage-dressing, a good deal of the trade in supplying ostrich feathers is carried on in the British Empire. In the famous ostrich farms of South Africa, the birds were first enclosed in 1857, and their eggs were first hatched by means of incubators in 1869. As the ostrich cannot jump, a wire fence five feet high is sufficient to form a bird camp. It usually contains one cock and two hens, that have a run of twenty-five acres. In wooded districts ostriches and cattle are combined in a farm; on the grass lands ostriches and sheep are reared. The feathers are cut or plucked once or twice a year, yielding from £1 10s. for low-grade birds to £26 for good birds. The highest authenticated yield for a bird is £30 a year. The plumes from the wing and tail of the full-grown cock bird are the most valuable.

In their system of breeding, the South African ostrich-farmers select the birds with the aim of getting a shorter quill and an increasing richness of plumage. Unless an ostrich feather is of exceptional quality, it does not have a sufficient number of flues to give it the mass that constitutes one of the chief beauties of a fine plume. So the manufacturer usually places several feathers one above the other, and sews them into a single plume, after removing the greater portion of the quill. The ordinary grades of plumes contain three or four ostriches feathers. The stem of the outer feather is left intact, and the others are sewn down upon it at intervals of an inch. After this the plume is stemmed; that is to say, an artificial stem of wire is sewn into it. The feather is then curled and bent, the latter and final process consisting of turning over the head of the feathers so that the flues are heavily massed.

Seeing that the lovely, graceful ostrich plumes can now be dyed to the most exquisite gradations of colour, and that boas and pom-poms and other feathery articles of feminine attire can be made in abundance from the domesticated bird, and seeing that cheaper feathers of every shape and hue can be manufactured easily from poultry and game, it is difficult to find any ground why wealthy women should continue to encourage the bands of wrongdoers who hunt down the beautiful creatures of the air which protect the bodies and the food supplies of the human race from disease and destruction. International legislation on a large scale, backed by a general system of penalising the sellers and buyers of the plumage of useful birds, is becoming—indeed, has become—one of the vital necessities of modern civilisation. It is doubtful which has wrought most harm, the slave trade or the plumage trade.

THE MAKING OF WEALTH

How Industry and Trade Have Always Been Checked by Under-Consumption

THE POSSIBILITIES OF EXPANSION

The essence of the production of material wealth is to form new combinations of the matter supplied by Nature, and industry and commerce alike are concerned with a useful exercise of motion. On analysis we see that all manufacturing is the issue in the form of useful articles of work done by moving into new positions the materials which Nature supplies. We cannot either create or destroy matter, but with increasing effectiveness we can create or destroy utilities. We do not create matter when we cut down a tall tree and turn its trunk into timber, but we do create a new utility—timber. We do not destroy matter if we burn the timber; the matter is indestructible, and all that we do is to reduce it to other forms—gases, smoke (unconsumed carbon), and mineral ash. The burning, however, has destroyed a utility, although it has not destroyed matter. It is not possible for man to waste matter; it is only possible for him to create or waste utilities by changing the form of matter.

But man is ever filled with a desire for new utilities. As his powers increase, and as his command of Nature increases, he demands an ever-increasing complexity of manufactured articles. His desires are without limit. He calls for houses of the most complicated description, for clothes and personal ornaments of constantly changing type and of great elaboration; he demands for the fuller enjoyment of his powers the constant use of an enormous range of utilities in the shape of prepared foods, furniture, utensils, books and papers, instruments of sport, musical instruments, vehicles, and so forth. The ever-growing facilities for the conduct of agriculture therefore serve to set free an increasing proportion of workpeople to devote themselves to manufacturing. The call for agricultural work has decreased, is decreasing, and must decrease. The call for the products of industry is ever growing.

Well-ordered movements produce wealth, but labour consists of movements not always well ordered. Labour, then, is the original source of wealth; but it would be a mistake to suppose that all labour produces wealth, for much of it is not well ordered. We have the further complication that what is a utility to an individual may not be a utility to the society of which the individual forms a part; and, as we saw in the last chapter, when we have estimated the wealth of a country and expressed it in currency, we have an estimate of wealth which may not be in entire accord with well-being.

In this connection arises the very important considerations connected with productive and unproductive labour. We pointed out in Chapter 7 that a person may be a useful "producer" although he is not directly engaged in constructing material commodities. This necessarily follows from the consideration that it is just as important to move an article into the place where it is wanted as to make the article itself. The pair of boots at the factory in the Midlands is useless to the person in Devonshire, where they do not make boots. The Devonshire man could not walk to Leicester or Northampton to obtain the boots; and the labour exerted, therefore, in conveying them from Leicester to a shop in Devonshire is obviously just as "productive" as that employed in making the boots themselves. The railwaymen, the carters, and eventually the storekeeper are seen to be truly productive in their movements.

But that by no means exhausts the treatment of this important point. It remains to add that while it is true that a conveyer of goods, or a storer of goods, or a dealer in goods may be a truly productive labourer,

it does not necessarily follow that every such conveyer or dealer is a wealth-producer. He may be producing something which is a utility in relation to the circumstances in which he is employed, but it does not necessarily follow that those circumstances are justifiable or that they could not easily be dispensed with.

Take, for example, the case of two small manufacturing firms engaged in the same trade. If we consider the nature of their operations, we see them renting two separate factories and two separate offices, and each employing a certain number of workpeople. Thus established, they compete in the same markets for an amount of trade which is limited by the consuming power of the buyers in the market. They each keep, of course, separate accounts, and find it necessary to print separate books, separate notepaper, and separate labels. They have also to employ separate clerical staffs, separate sets of travellers or agents, and they issue separate advertisements. It will readily be perceived that each of the persons engaged by the two firms is producing utilities under the given circumstances; each of the clerks and travellers is necessary under the given circumstances.

How the Duplication of Businesses Makes Part of the Labour Employed Non-Productive

The point remains, are the given circumstances necessary? And from the point of view of society, is each of the persons employed by the two firms producing social utilities? If we imagine the two firms to combine their operations, we see that they would not require separate offices or separate accounts, or separate travellers or separate advertisements, and that it would probably be as simple, or even simpler, to manage the two businesses as one than to manage the aggregate business as two. Given fresh circumstances--viz., amalgamation of the two economic units into one economic unit—and a certain considerable amount of the labour before employed by the two separate firms is seen to be economically useless, and productive not of social utilities but of social waste.

The mere fact, therefore, that a man is at work, and working strenuously in that work, does not necessarily mean that he is a productive worker. Through no fault of his own, but through the imperfect organisation of trade, he may be doing work no more valuable to society than if he were digging a hole, and filling it up again. There can be no doubt that in a community of over 45,000,000 of people such as the United Kingdom possesses in 1912, the number of persons who, although they work arduously, are not really engaged in adding to the wealth of the country, is very great indeed. Indeed this will be apparent from a further consideration of the remarkable facts which were stated in Chapter 7 as to the number of persons in the country actually engaged in the direct production of material goods.

The too-ready consent of the classical economists to the neglect of the very real distinction between productive and unproductive labour, which we have examined has been answerable for a certain neglect of the proper study of production and producing factors in relation to distribution.

An Erroneous Professorial View of a Carpenter "Making" a Table

It is never enough to say that people are employed or unemployed; it is all important that we should know *how* the employed are engaging themselves. We often find economists, in their anxiety to abridge the distinction between productive and unproductive labour, denying that man can "create" anything, and asserting that it is a careless use of language to speak of a carpenter, for example, as "making" a table. As a matter of fact, a carpenter who asserts that he has made a table is much nearer the truth than the professor who denies the fact. It is perfectly true that a carpenter does not create the matter out of which the table is formed, and that the table is an expression of his skill in utilising natural materials and his wisdom in so fashioning the materials that they take form as the entity we call a table. A table, however, is not wood, but a created utility embodying the skill, the experience, and the judgment of men; and as such it is a real creation.

The Dependence of True Employment on Whether a Man is Creating a Utility

That cannot be said of the products of the unnecessary clerk making a superfluous invoice, or of a little boy (who ought to be at school) carrying golf-clubs for a gentleman, or of an able-bodied man told off to mark billiards, or of ten shopkeepers doing a distributive trade which could be conveniently carried on by one-fifth of their number. It is false to conclude that all those whose labours satisfy existing wants are to be truly regarded as taking part in production, or that they can be called productive labourers. It cannot be too

strongly insisted upon that honest and arduous work may be, and undoubtedly is, often exerted in forms which are without advantage to the wealth of a nation, and that it may but serve to attenuate the earnings of those who produce usefully. It is only too true that in the United Kingdom, or in any of the great modern civilisations, a limited number of economically employed workers carry on their backs a host of workers whose work is poured out in waste, and who, themselves not really producers, consume the products made by others.

The Mistake of Supposing that the Army and Navy are not Productively Employed

What we have said is recognised by many people to be true in respect of the Army and Navy. The United Kingdom has a population in 1912 of over 45,000,000, of whom about 12,000,000 are male adults. Of these 12,000,000 males we employ about 125,000 for the Navy, and about 240,000 for the Army ; or, say, 365,000 men in all. We often hear it said that these 360,000 men are idlers who consume without producing, and in one sense this is incontrovertible. They are picked men, our soldiers and sailors, and we train them in physical exercises to make them strong and efficient. How much they might do, we often hear it said, if they were trained also in productive work, and set to produce material good for consumption! If we take their output as worth no less than £100 a man per annum, *we should have an addition of £36,500,000 to the goods produced in the country in a year.* It is useless to repine on that account, because we know that these men are needed, in view of the circumstances of the imperfect civilisation and settlement of the world ; and if we regard them as guarding the nation as a whole, they may claim to be as useful as any other members of the community. Indeed, our soldiers and sailors may claim to be much more useful than many other groups of men and women of similar proportions that could be named as wasting their time, and consuming goods which they do not produce.

The Effect of the Distribution of Wealth on the Character of Production

The number of economic hangers-on in our great civilisation far outnumbers our soldiers and sailors. Like the personnel of the Army and Navy, they consume goods which someone has to make, while they themselves add nothing economically useful to the national undertaking.

The manner of the distribution of wealth in a country has a profound effect upon the course of wealth production, or, what is to say the same thing, upon employment. It is not necessary here to make an analysis of the distribution of wealth, but everyone is aware that great inequalities of fortune obtain in all the great nations of the world. We pointed out in the last chapter, in our study of accumulated wealth, that of about £300,000,000 which is left by those who die in an average year in this country, as much as £200,000,000, or two-thirds of the whole, is left by only 4000 persons. That fact, if it stood by itself, would be sufficient to prove that we are not misled by our senses when we come to the conclusion, from ordinary observation, that the distribution of wealth is exceedingly uneven. We may add here that it is probable that about one-half of the entire income of the country is enjoyed by about 5,000,000 persons only—*i.e.*, by about one-ninth of the entire population—leaving the remaining half of the national dividend to be enjoyed by eight-ninths of the population, or, say, 40,000,000 people. The consequences of a distribution of this character are far-reaching ; and their effect upon trade and industry deserves our closest attention.

The Greater Call for Labour that Comes from the Most Widely Distributed Wealth

It will be realised that a call for commodities is, in effect, a call for labour. As we spend our money, so we direct people to work for us. If we call for clothes, we employ men and women in the textile and clothing trades, and indirectly we call planters to grow cotton and graziers to raise sheep. If we elect to be less fine in our persons in order to secure better houses, then we command men to come into the building trades, and we command the various trades of brick and tile making, the making of glass, the making of cement, etc., to supply materials to the builders of our homes. If, careless alike of our homes and of our persons, we spend large parts of our incomes upon alcohol, we direct employment away from useful trades, and command men to enter the employ of brewers and distillers. If we become a pleasure-loving people, and spend a considerable part of our incomes upon amusements, then we inevitably turn men and women into actors and actresses, professional singers and dancers, builders and furnishers of places of amusement, professional cricketers and footballers, and so forth. Clearly realising this, we perceive that the total production of the country, the nature of the production of the country, and therefore the character

of its trade, must vary with the manner of the distribution of wealth.

The man of small and moderate means—we speak of the average, healthy, decent man—spends by far the greater part of his income upon the necessaries of life. Indeed, he is compelled to do so if he is to keep his home together and his family in modest comfort. The first requisite is a home, and so much has to go in rent; the second is food; the third, fuel and light; the fourth, clothes. As incomes rise in the scale, the proportion of the expenditure of income upon these things varies, and other things are called for in increasing proportion. We may note that, however big a man's income gets, he does not increase the call for certain things very materially. He does not grow additional feet with his additional income; and even though he has ever so ample a supply of footgear, there is not the same proportion of his income spent upon boots as in the case of the man with 35s. a week. The existence of a limited number of very large incomes taking a great share of the national dividend, and of a larger number of very small incomes, must mean that the trades of necessity are not nearly as large as they would be if there were a more equal division. The rich man, by his expenditure, encourages the trades of luxury more than the trades of necessity.

How Great Wealth Tends to Call Economic Idleness Into Being

If five millions of people have the same amount of income as another forty millions of people, then the five millions have as great a call for labour through expenditure as the forty millions; and it follows that the call of the five millions must turn away from the serving of the majority a very large proportion of the labourers of the country, and command them to serve the well-to-do. This takes effect in many different ways. For one thing, of course, it calls into sheer economic idleness a very large number of people who become menial servants, attendants, pleasure providers, and so on. For another thing, a considerable proportion of what are nominally trades of necessity come to serve a limited number of people.

It does not follow, because a man figures in the Census returns as following a useful occupation, that he is economically employed from the standpoint of national well-being; his services may be monopolised by a well-to-do man who has the sole call upon them, and turned into wasteful channels. A bricklayer may be found engaged upon a palace of folly; an electrical engineer may be found doing work for one man which might equally serve fifty.

If we consider one of the greatest of trades, that of housing, we see how greatly it is affected in this way. We have not yet the report of the Census which was taken in 1911, but at that of 1901 it was shown that in England and Wales alone there existed nearly 3,300,000 tenements of fewer than five rooms each, and of these nearly a million consisted of one or two rooms each. Let us imagine what would happen if suddenly those who live in these tenements had the means of commanding decent houses. The building trade as it exists would be quite unable to cope with the demand for new building work.

The Stimulation of the Building and Other Trades if the People Were Well Housed

We may say of the building trade as it is that it would employ many more men if all the families in the United Kingdom could command—we will not say good, but merely moderately good—accommodation. And because one trade employs another, we see further that if the building trade could be thus stimulated it would make a call in turn upon the timber trade, and the brick trade, and the cement trade, and the glass trade, and the iron and other industries, for a vast amount of useful material.

The Census of Production gives us some very illuminating details as to the extent of the building trade. The particulars which were obtained by the Board of Trade from the builders of the United Kingdom in 1907 are given at the foot of the next page. In addition, there was a large amount of railway and permanent way construction, bridge-building, sewer construction, harbour-making, waterworks construction, and so forth.

The Poorness of Housing Proved by the Amount Spent on Repairs

It will be seen that the construction, alteration, and repair of private houses and of trade and business premises was of a value of about £64,000,000 in the year reviewed, which was a year of very good trade, and that of this sum we may perhaps take it from the figures given that about £36,000,000 was spent on new construction and about £28,000,000 on alterations and repairs. Consider first the latter figure. It is not a little remarkable that 9,000,000 separate premises, many of them, as we know, of an advanced age, should have spent on them in a year in repairs, alterations, and decorations no more

than £3 each on the average. We know how little £3 means in the way of a builder's bill for repairs, and we have therefore vividly brought home to us in the bulk what we know to be true in detail—that a very large proportion of our houses are in a very poor state of repair.

Then let us turn to the new buildings. We see that 45,000,000 of people call in a year for no more expenditure upon new private houses and new trade and business premises than about 16s. *a head*. We think of building as a big trade, but we realise, in view of this analysis, what an enormous trade it might be if rates of wages and salaries enabled the great mass of the people to call trade into existence by a proper expenditure.

Or take the cotton trade as an example. There are about 9,000,000 families in the United Kingdom, averaging five persons to a family. The uses of cotton are so considerable, not only for garments but for household purposes, that even a very modest standard of comfort would demand an expenditure of, say, £10 per family per annum (factory value) on cotton goods of all sorts, from calico to thread, from towels to window curtains, and from shirtings to lace. Let us think what it would mean if our 9,000,000 families were so situated that they could spend not less than £10 per family per annum on cotton goods, while a small proportion of them spent more. Here is a statement of the case.

A HYPOTHETICAL MODEST CALL FOR COTTON GOODS

	£
5,000,000 families spending £10 per annum	50,000,000
3,000,000 families spending £15 per annum	45,000,000
1,000,000 families spending £30 per annum	30,000,000
Total	£125,000,000

Thus we have a hypothetical expenditure of £125,000,000 per annum upon cotton goods in the home market alone, or nearly as much as the *entire* output of the British cotton trade now. But eight-tenths of the production of the British cotton trade, as it is, is exported, so that such a modest home expenditure as we have imagined would *nearly double the output of the Lancashire cotton trade*. We are accustomed to regard the cotton trade as an enormous one, and we take great pride in it. It is not suggested here that the conception is wrong, or that the pride is unjustifiable. It is, however, suggested that, great as the trade appears to be, it is susceptible of an advance of great magnitude, and that a very much larger number of persons would be employed in it if the consumption which is now latent became actual. The Census of Production Report shows that in 1907 the average number of persons employed in the industry was 572,869—viz., 560,478 wage-earners and 12,391 salaried persons, the total number being distributed according to age and sex as shown in these figures.

MALES	
Under 18 years of age	51,709
Over 18 years of age	168,854
FEMALES	
Under 18 years of age	90,061
Over 18 years of age	262,245

The number of persons employed in this trade—less than 600,000—would be greatly increased if consumption rose to a better level, and they could easily be spared from the uneconomic tasks which now occupy them unnecessarily.

Thus it is also with the woollen and worsted industries. The output of these industries at the present time is worth about £75,000,000 per annum, and of this £37,000,000 is exported, leaving for home consumption £38,000,000 a year. There are imports of woollen and worsted goods

OUTPUT OF THE BUILDING TRADE IN 1907

—	Construction	Alteration and Repair	Construction, Alteration, and Repair, not Separately Distinguished	Total
	£	£	£	£
Private premises (residential, trade or business)	32,025,000	23,782,000	6,825,000	62,632,000
Public premises	5,732,000	1,319,000	469,000	7,520,000
Places of public worship and buildings connected therewith	1,537,000	544,000	190,000	2,271,000
Private premises, public premises, and places of public worship, not separately distinguished	65,000	49,000	877,000	991,000
Total buildings	£39,359,000	£25,694,000	£8,361,000	£73,414,000

to the value of about £8,000,000, so that we may put the total home consumption at about £46,000,000 per annum for our 45,000,000 of people, or rather more than £1 per head, or £5 per family. This is very remarkable, for our climate is a capricious one, and there are few months in the year when a person of either sex does well to dispense with woollen garments of some sort, to say nothing of the very great uses of wool in the household in carpets, upholstery, and other furnishings, and its use also in vehicles, etc.

It is really difficult to form the most modest estimate of consumption of woollens by a family of five persons which does not work out at over £10 per family per annum, and £20 per annum per family would by no means be an excessive allowance. But what would £20 per family per annum mean? It would mean an output by the British woollen and worsted industries, *for the home market alone*, worth £180,000,000, and that, added to the existing export trade of nearly £40,000,000, would give a total output of about £220,000,000. Again we see what a difference there is between the trade there is and the trade that might be if the great majority of people were able to satisfy a moderate demand for the necessities of life.

The number of persons employed in the woollen and worsted industries, although actually great, is relatively small when we consider what ought to be the actual demand for woollens by so great a population living in a country which usually has seven months of winter, and in some years has more. The Census of Production of 1907 showed that the average number of persons employed in that year was 257,017, the number being distributed as to age and sex as follows:

MALES	
Under 18 years of age	21,953
Over 18 years of age	89,485
FEMALES	
Under 18 years of age	34,087
Over 18 years of age	111,492

The 258,000 woollen and worsted employees would be greatly multiplied if consumption were raised in the way we have pictured; and, of course, the devotion of a larger proportion of the population to the making of woollen and worsteds would mean the drawing of workers out of trades which are now economically useless, or even injurious, to the national welfare.

The boot trade furnishes another striking example. The Census of Production of 1907 gives a careful analysis of the output of factories and workshops engaged in the manufacture and repair of boots, shoes, slippers, clogs, etc., whether of leather, rubber, canvas, or other materials. The official summary of the principal products of boot and shoe factories and workshops is as in this table.

PRODUCTION OF BOOT AND SHOE FACTORIES IN 1907

	Quantity Pairs	Value £
Boots, shoes, and slippers..	97,762,000	20,023,000
Clogs	1,441,000	165,000
Leggings and gaiters..	Recorded by value only	109,000
Socks for boots and shoes		45,000
Leather laces		38,000
Other products		29,000

The total value of the above goods is little more than £20,000,000; and it will be seen that the number of pairs of boots, shoes, slippers, and clogs is a little over 99,000,000. We know from the export returns that of these about 17,000,000 pairs are exported. It follows that the home market is satisfied by two pairs of footwear per annum for each person. Again, if we take a most modest estimate of consumption, and merely suppose each person to call for two pairs of outdoor boots or shoes, and one pair of indoor boots or shoes in the year, we see that the output of the British boot industry would at once be increased by about 50 per cent. to supply the home market.

As a consequence of the facts related, the Census shows that the number of persons employed in boot factories and workshops in 1907 amounted to 117,324 wage-earners and 9,240 salaried persons, a total of 126,564 persons, distributed by age and sex thus:

MALES	
Under 18 years of age	15,052
Over 18 years of age	75,902
FEMALES	
Under 18 years of age	10,806
Over 18 years of age	24,804

Even when it is taken into account that there were, in addition, about 14,000 outworkers, wholly or partly earning their living in the boot manufacture, we see that the number of persons employed in what is, in such a climate as ours, one of the most necessary of all trades is comparatively small, and that a better distribution of income, by increasing the expenditure of the average household, would call into this respectable trade many additional workers.

But far more striking even than the cases of cotton, woollens, and boots is that of

furniture. The Census of Production of 1907 showed that the total output of furniture factories and workshops in the year 1907 amounted to about £17,000,000, in the proportions that follow.

PRODUCTION OF FURNITURE AND UPHOLSTERY FACTORIES IN 1907

	Value £
Furniture of wood, upholstered or not upholstered	7,449,000
House furnishings, not otherwise specified	6,027,000
Bedding, cushions, etc.	1,471,000
Fittings for shops, offices, banks, churches, ships, etc., and architectural woodwork	1,120,000
Blinds	554,000
Wire mattresses	161,000
Bamboo, basket, and wicker furniture (including perambulators)	90,000
Other products, not furniture or furnishings	158,000
Total	£17,036,000

Even of the £17,000,000, it will be seen, no small part is composed of shop and office fittings, etc., and not of household furniture. Here, indeed, we have brought home to us the extraordinary disparity between the need for goods and the existing call for goods—between the trade that is and the trade that might be.

The call for furniture, of course, comes after the call for boots and the call for clothes; and it is not too much to say that the number of houses in the United Kingdom which are well furnished is barely 10 per cent. of the whole, if as much. To witness the removal of the household belongings of a poor family is one of the sorriest sights imaginable. To look at the nature of the furni ure and upholstery which is offered for sale to the poor is only a degree less depressing. Even with the aid of the now very extensive hire system, it is exceedingly difficult for the working and lower middle classes to acquire a decent amount of solid and comfortable furniture. The Census of Production figure means that the average family in the United Kingdom *spends less than 38s. a year*, plus retail profit, on furniture and upholstery —including office furniture, etc. That is to say, what might be and what ought to be a trade of enormous dimensions is restricted within very narrow limits.

The number of persons employed in making the £17,000,000 worth of furniture, etc., number only 91,412, being 83,274 wage-earners and 8,138 salaried persons, distributed by age and sex as shown :

Males	
Under 18 years of age	14,226
Over 18 years of age	64,126
Females	
Under 18 years of age	2,872
Over 18 years of age	10,188

Now let us endeavour to formulate some idea of a modest standard of comfort in the furniture line. Let us suppose that each family in the United Kingdom spent no more than £10 a year in maintaining the comfort of its home. That would mean a home trade worth £90,000,000, as against the present diminutive figure. It would mean, of course, the employment, and the worthy employment, of a very large number of people in trades in which, under decent conditions of labour, it is a pleasure to work—trades which call not only for skill but for taste.

The more closely we pursue our inquiries, the greater the number of trades we examine in detail, the more we are impressed by the under-consumption which still obtains at the beginning of the second d cade of the twentieth century in this, one of the wealthiest of countries. There can be no question that the ill distribution of wealth has much to do with this under-consumption. As soon as a limited number of people, by obtaining an undue lien upon the national dividend, call out of the trades of necessity into the trades of luxury a large proportion of the population, it must necessarily follow that production is checked, and, further, that what production there is cannot be of the most desirable kind.

It is of the greatest importance that the present character of consumption should be realised, because, if it is not taken into account, we are only too apt to imagine that the trade of a country like the United Kingdom finds its chief hope for the future in foreign as distinguished from home commerce.

Such a conception amounts to a profound error. We cannot have it too clearly in our minds that the first object of British industry and British trade is to provide for the British citizen a liberal subsistence, and that in the 45,000,000 people of the United Kingdom we have a magnificent market, which is yet susceptible of indefinite expansion. The present home trade needs to be not merely doubled or quadrupled, but multiplied tenfold, before we can afford to be complacent as to the amount of comfort possessed by the masses of the people who manufacture comforts.

THE COMMANDER-IN-CHIEF GIVES BACK REPRESENTATIVE GOVERNMENT TO ENGLAND

During the Commonwealth, England, rescued from kingly tyranny, fell temporarily under the rule of the army, till Monk, the Commander-in-Chief, declared for a free Parliament, and representative government was resumed.

CITIZENSHIP AS A STUDY

The Importance of the Public Understanding Public Rights, Privileges, and Duties

THE GREATEST GAP IN EDUCATION

As we have commented on local attempts to make each village and town approximate more and more to an ideal dwelling-place, a genuine social gathering-ground, where every citizen will help the rest and no one be a danger, and as we have discussed the relations, in administrative work, between the central government authorities and the district governments formed by the ratepayers, the doubt has recurred constantly whether today popular government is popularly understood, and, indeed, whether any serious and consistent attempt is made to cause the young to know the broad facts, or the old to reflect on the broad principles of government. In view of the spread of citizenship to all, is any adequate effort being made to give to all a clear view of sound citizenship?

Quite obviously it is necessary that, if the government of modern nations is to pass into the hands of the populace through the universal vote—and that is what is here, or is at hand—the thought of statesmen, educators, and moralists should be concentrated on giving the populace easy opportunities of understanding the foundation principles of civic justice, helpfulness, and stability. In brief, the subject of civics should be regarded as the first study for every man, after he has learned how to work to keep himself and those dependent on him. It has, too, a direct bearing on that work of maintenance. And yet no fully organised attempt has ever been made to give this great subject an adequate place in the scheme of education for the young, or for those on the threshold of citizenship.

Such neglect could well be understood in former days, when government was in the hands of a few—of kings and their Courts, of the gentry, of the middle classes, or of any limited number of selected people. There was no reason why the many should be taught to understand the value of privileges and legal rights they did not possess, except with a view to broadening ultimately the basis of the political edifice. A haphazard knowledge might suffice for the many when it was unconnected with responsibility. But now all that is changed; and the man who has never given a minute's serious thought to public institutions or affairs will have as much voting power—though, of course, not as much influence on votes—as the profoundest publicist. The least that can be expected of the nation with a universal suffrage is that it shall take the trouble to organise a readily accessible education in the business on which the suffrage is exercised—that is, in the business of public government.

Yet it may be doubted, with grave conviction, whether the bulk of the people of this country—or, at least, that part of the people that exercise the privileges of popular government—have as full, reasoned, and individually accepted a knowledge of civics as the men of a corresponding type had in the middle of the nineteenth century. In those days the number of keen reasoners whose minds were whetted on public affairs was very large, in proportion to the number of the population.

There were reasons why it should be so. Whole blocks of the population were suffering under severe restrictions, and larger blocks had no political power. Nonconformists, for instance, were denied equal treatment in education, public life, and even burial, and the spirit that kept up these injustices to the last moment of possible resistance permeated society in many ways. Jews, Roman Catholics, all people without property, all people living in a house rated below a certain figure, were under a public limitation, if not a ban, prescribed by law. The pressure of these

restrictions made people think. There is nothing like injustice for making people think, earnestly and deeply; and the men of those days had examined for themselves the foundation principles of all government, and had been helped in their search by the serious philosophy of a thoughtful Press, written by thinkers for thinkers.

It is all strangely different now, and the current of public life runs with a broad and brawling shallowness. Today everybody has public rights which many value at a very low assessment, unless they fancy their pockets are immediately touched. The average man expects everything to be done for him by somebody else, and his own duties fit him very loosely. Instead of regarding public power as a priceless privilege for which his fathers suffered to the extremes of martyrdom, it is rather a chance for self-complacent patronage of some person who is known, or some cause that, for the moment, seems to be "the thing," judging by the newspaper headlines.

The Failure to Spend Individual Thought on Public Affairs

The newspapers themselves are diligent in providing ready-made excuses for a want of thought. They plant causes on their readers in much the same way that they suggest fashions to the domestic circle. They give the impression that certain things are what people are believing and thinking and doing and wearing—it is all one "swim."

That there is an immense amount of this unthinking acceptance of anything that seems to be "going" may be seen in the quality of the arguments that are thought to be good enough for the modern newspaper reader. Suggestions that no self-respecting man would dare to make in any private circle of intelligent persons—as, for example, explanations of the momentary course of public events—are brazenly given to a silly public, because it is known that many will be quite ready to accept them without a moment's thought if they jump with political inclination; and others will laugh at the audacity which coolly bamboozles the "tenderfoot" politician with arguments which no sane, experienced man believes in.

Is this too strong? That it is not may be put to a simple test. Is there a single fallacy held by mankind in the course of their intellectual evolution that could not be advanced today in the popular Press, boldly, by editorial fiat, and be received without a flicker of doubt by the read-as-you-run subscriber? Take such a fallacy as the mercantile theory, exploded for all time by Adam Smith, and who will say that a restatement of that theory would not be received by the ordinary newspaper reader of today as Heaven-sent wisdom? The truth is that as popular government has extended, accompanied by the ministrations of the cheapened Press, a real knowledge of the principles of citizenship has declined. Politics are a subject-matter of news, not of thought.

The Possibility of Expounding Civics Apart from Immediate Politics

If this statement of the position is anywhere near the truth—and we contend that it outlines very serious truth—there must be good ground for urging that civics should be made an important, regular part of our school system, and be sedulously taught in after life. By civics, of course, we mean public polity apart from the politics of the hour.

But it may be said that citizenship cannot be expounded without reference to politics, and that it would never do to have party politics involved in school curricula. We suggest that there is not the slightest need for any such contingency. As religion can be inculcated entirely apart from sectarianism, so civic organisation, civic principles, civic patriotism, and history can be presented without any reference to the party controversies of the moment; for men of every party complexion are in essential union with regard to the great elementary conceptions of government.

The Preponderating Advantage of Party Conflict, National and Local

In thus putting aside from the schools the idea of discussions that would involve party feeling, let it not be supposed that we join in the common denunciations of party warfare as something inimical to good government. In elections to the central legislative body, of course, party strife will be conspicuous; and we are further prepared to defend its adoption in local contests. It is perfectly true that a large proportion of the work done by local authorities in administrative directions has no relation to national politics, as they are commonly understood. Whether a new street shall be planned for the public convenience, and how it shall be paved, are questions on which party colour can give no lead. And yet experience shows that even small local elections may be run with advantage on party lines, though party interests are not involved by the nature of the business to be transacted.

The most important consideration is the choice of suitable men for administrative work, who will not take a petty or personal view of public business. Now that is much more likely to be done efficiently by party organisations than by cliques, or the self-selection of pushing persons. Parties are bound by their self-respect to have some care in adopting candidates. They know that a foolish choice will react against themselves as a party. Besides, the mere fact that a man belongs actively to one or other of the parties is presumptive evidence at least of interest in public work. Party approval means that a form of preliminary selection has been observed, probably with the effect of eliminating the wholly unsuitable. Under any system of free and unorganised choice there is always a danger of individual self-sufficiency getting a place beyond its deserts; and experience has proved, in innumerable cases, that no constitution of the personnel of a public body is so ineffective as a chance agglomeration of individual self-seekers. Public interest is killed where there is no clear line of division in the choice of public men.

Interest the Truest Touchstone and Test of Civic Competence

Of course, in all local elections, where broader questions of political policy are not involved, many voters will favour the man who is thought to be ablest irrespective of party colour, and in that way any ill-effects of a party choice are neutralised; but the general sifting of candidates by party organisations remains a helpful part of the process of government, and one that need not be burked or denied or disparaged. Party government that does not admit of corruption is a reputable resource which is not in need of any apology. It is one of the buttresses of the civic fabric, and should be appreciated and not discounted by anyone who undertakes to interest the public in citizenship.

The true touchstone for initiatory participation in the government of a country in any capacity, whether as a voter, an administrator, or a legislator, is *interest*—individual, keen, and public spirited. If interest is sufficiently strong it will bring knowledge; without interest, the so-called citizens are a fluid mass, drawn hither or thither by any tide of chance feeling, if they are moved at all. Indeed, the right to vote should be dependent on the elementary qualification of having some personal care for public affairs. No harm would be done if every man—and why not every woman?—who has an individual interest in civics, and will take some trouble to show it, were allowed by personal action to register as voters, provided nobody was registered who did not display that personal care for public affairs.

A Suggestion for Making the Franchise Represent the Nation's Real Mind

If every citizen had to attend at a public place, take out a warrant of citizenship, and, say, pay a shilling, and renew that warrant every ten years, something would be done towards getting rid of the farce and indignity of the utterly uninterested voter, who has to be entreated and cajoled into voting often by people who themselves have no vote. All who care would have votes, many who do not care would leave themselves off the list, and the true opinion of the country, spontaneously formed, would be more nearly obtainable.

Now, the demand seems to be for more and more voters, irrespective of interest or the knowledge that follows interest—as if numbers had any value in themselves, apart from the exercise of individual judgment. If the responsibilities of citizenship were something to be won, or formally adopted, as a member of Parliament, or a city alderman, or a justice of the peace signs a roll promising to faithfully fulfil his office under conditions legally laid down, then there would be an incentive to a thoughtful study of civics, and the need for a formal training in the principles, duties, and responsibilities of public government would be seen without argument, and would be met earnestly and promptly, and the greatest gap in education would be filled.

What are the broad ideas of civics that should be taught to the young, without controversy, and known by the old without doubt? We cannot, of course, cover the ground completely here, but we may indicate its range by mentioning eight or ten points. We may summarise the whole first—perhaps it should be last—by saying that every citizen should have a general conception of what his country stands for in the world.

The Need for Knowing what One's Country Stands for in the World

The central ideas of great nations have often changed, but those of the British Empire have remained fairly constant, and will hardly be improved. France once went far astray after a vision of glory. Has Germany a central aim, beyond the brute force movement towards expansion which crowds history with illustrations? Who can say? The United States seemed to be taking the

line of moral supremacy, with rational peace-making as a worthy goal; but failure is likely to come with the first real test when she enters the circle of the nations with interests of her own involved in Panama. Orderliness, humanity, fair dealing, and the open door have been the British ideals everywhere, with extensions of liberty as different peoples have been fitted to receive it. The whole nation has a deep-seated belief in fair play, and the world at large knows it has it. From that spirit springs the magnificent fact, illustrated again and again on the grandest scale, that our country cannot willingly commit an injustice. Whoever understands that has penetrated to the heart's core of British citizenship.

The Need to Realise a National Constitution as an Organic Growth

Of course, the student of citizenship should have acquired a general idea of the upbuilding of our national institutions and the fabrics of government, from the parish council to the Cabinet, which so often has to act as a power above Parliament; and in doing that he will realise, if wisely guided, the enormous difference between a practical government that is a living organism, growing out of the wants, history, and aims of a nation, and changing with its growth, and the so-called ideal States which philosophers imagine and which remain dead plans. The British Constitution as a whole, and in every part of it, is unideal, full of inconsistencies, offering invitations to criticism, sometimes almost dangerously absurd; but it works. And if one watches long enough how it works, the conviction grows that it represents, in a remarkable way, the genius and aims of the nation. The fact is that its slow changes have kept pace with the growth and expansion of the nation, neither falling behind nor going too far ahead, and the result is a widespread conviction that we are well served by our system of government, and that it suits us, however illogical it may be in parts if criticised by the light of pure intellect rather than by experience.

The Need to Warm Our Hearts by the Enthusiasms of Long Ago

We have already commented - in our last chapter—on the distinction, too little realised, between legislative and administrative action. Comparatively few people who are not engaged in public work understand how wide is the gap between laws on the statute book and laws actually put into force and vigorously carried out. An enormous percentage of laws to all intents and purposes are "dead letters," and will be till more people have an intelligent conception of what may be done by means of laws now existing. It should be one of the aims of a movement to teach civics that present possibilities should be more fully realised.

A soundly based conception of the government under which we live, and which we help to carry on, will not be formed, with heart and sentiment involved as well as dry knowledge, unless we know something of the story of how the liberties of today were won. The story of British liberty is the story of the world's emancipation, as far as it has gone. The so-called democracies of antiquity were not democracies at all according to modern ideas. The battle of popular government was won in essence when Hampden, Cromwell, Milton, and Monk, in their various ways, made the stand which established Parliament for ever as the vital governing force of the land—established it so firmly that the return of the Stuarts could not undermine, though it shook somewhat, the foundations of national liberty.

The Need to Understand what Parliament Can and Cannot Do

In reading the story of the emergence of the spirit of liberty in the past it is not wise to suppose that that past holds lessons which give exact guidance for the future. Every age has its own problems to solve in new ways. But whoever misses the story of constitutional, social, and industrial growth misses much of the glamour and inspiration that give colour and intensity to the civic developments of today. What we are and what we shall be nationally are based on what we have been; and we must not rob ourselves of the conscious glory of being the children of heroic forefathers.

Three respects may be mentioned in which the trend of modern politics seems to show a strong need for a truer realisalion of civic possibilities and impossibilities. Evidently there are vast numbers of people who have never understood what Parliament can do, and what it cannot do. Probably half the speeches made from public platforms—quite three-fourths of the speeches made by women—are based on utterly unsound assumptions as to the power of Parliament. Much more are they mistaken as to the power of the vote. From the giving of a vote to the accomplishment of revolutions is a long, long way, especially when, in the course of the journey, it is expected that the Parliament of the nation will do things for which it is quite unfitted.

It cannot, for example, fix the economic

conditions under which production and exchange take place throughout the country and the world, any more than it can arrange the weather and determine the harvests. So deep is the popular ignorance that one may hear speakers promise, amid popular approval, to do in a few weeks, if they are trusted, what Parliaments can never do in an eternity of effort, inasmuch as it is not within the province of legislation to do anything of the kind.

Again, a sound knowledge of civics should include acquaintance with the aims and methods of other countries; a theory of what our relations with those countries should be; a conception of their rights throughout the world, and of our rights which no State should wish, or threaten, to infringe. Who can deny that in this country, at any rate, there is a tendency to err both through excess of national consciousness and susceptibility and through a failure to judge ourselves aright in comparison with other races? With the one set we and we only are the people. With the other set we are sure to be wrong whatever we do, and however plain are the evidences that our action is for the general good of the world. There is never any need for foreign criticism of British action — the home-bred critics will suffice. What wonder that such curious divergences as we have noted—both dangerous—arise when there is no pretence at any national school of thought or polity, so far as foreign relationships are concerned? Yet they may be vital to our citizenship.

JOHN HAMPDEN, THE FOUNDER OF MODERN LIBERTY, REFUSING TAXES.

And, lastly, fresh attention is needed to education in civics because of the growing laxity in judging the true place of law in the land. All the world over British rule has been, and is, distinguished by the reign of the law. Means for altering the law are available everywhere—not theoretically only, but practically. All that is needed is the convincing of a majority. To the law every decent citizen has bowed in respect, and the general result has been profoundly satisfactory. Go into the great Western agricultural regions of Canada that are now being filled rapidly with some of the best types of American farmers, and ask what impresses them most under the British flag, and the unvarying reply is that the finest product of the British spirit is the order that exists without effort. The law runs everywhere, and is sacred, and men benefit amazingly in consequence. But this most British of conditions is being misunderstood and endangered in the very homeland. In the name of religion first, then in the name of political agitation, and soon, apparently, on behalf of any childish crank the law is to be defied by private judgment or fanatical whim. When this kind of thing is not only practised but gloried in as a fine example of public spirit, the time surely has arrived when fundamental teaching as to the place of law in any nation of free lawmakers should be given as a necessary antidote.

Our last word must take a personal turn, for, after all, public life is largely personal. When civics have been carefully taught in schools along the broad lines faintly indicated here, and when we have a generation of voters who understand, and view with interest, the various phases of public life, the government of the country, locally and imperially, will depend largely on a choice of men. It is the manning of the public services, voluntary and official, that matters most; and part of the training in civics should be concerned with appreciation of the qualities that make genuine statesmen and sound administrators. The right men will work almost any system, however imperfect. The wrong men will fail to use the most ideal arrangements. It should be the pride of a free democracy that it knows how to choose, and has been trained how to choose, its representatives in office from those who are public-spirited beyond a doubt, incorruptible, essentially fair-minded, open to the influence of facts, businesslike in action, experienced in the work to be done, and animated by a lofty sense of the final possibilities of their country and of humanity. Only knowledge in the electorate, based on a study of civics, will enable a democracy to be established on justice.

AN EASTERN STUDY BY MR. W. H. MARGETSON, ENTITLED "THE CRADLE OF PEARL"

This picture is by permission of Messrs. A. Vivian Mansell & Co., and the portrait on page 3173 is from "The Century of the Child," Putnams

EUGENICS THROUGH LOVE

The Life of Ellen Key, and Her Writings on Love, Marriage, and Divorce

THE TWO DIVIDED CAMPS OF EUGENISTS

WE come now to the work of a living woman who is, in the judgment of the present writer, the highest and the deepest of all writers on eugenics. Her name is scarcely known yet in this country, where the writer has been proclaiming it for years without any sign that it was known to those who heard it; but when he named Ellen Key as the champion of a certain great doctrine—Eugenics through Love—at the recent International Eugenics Congress, a host of foreign delegates applauded her justly famous name. We owe to Dr. Havelock Ellis her introduction, at last, to the English reading public, to whom two of her books have been now supplied by Messrs. Putnam's Sons. The first of these two books, for which the publishers have earned the gratitude of all serious members of the "Anglo-Saxon race," is called "The Century of the Child," and need not detain us here. It is a great plea for the right of the child to be well born and well nurtured, and contains some wonderful chapters on education. But for our present purpose we must pass on to the second book, called "Love and Marriage" in its English dress, which has been translated directly from the Swedish, and was published in 1911, with an introduction by Dr. Havelock Ellis. This is the author's most important work, surely destined to have a profound influence upon the development of mankind, and, above all, upon the progress of eugenics during the present century. A few facts about Ellen Key herself—far fewer than will satisfy students of this great woman a generation hence—may first be noted.

Just as the supreme philosopher of Germany, Immanuel Kant, was partly Scottish, his name being the Scottish Cant, so Ellen Key is partly Scottish, and her name, which is pronounced to rhyme with "my," is really the Scottish "MacKay," having lost the prefix. She is therefore Scottish as well as Swedish. She was born in Sweden in 1849, on a country estate of her father, and was early influenced by the two great writers of Scandinavia, Ibsen and Björnson, though scarcely less by certain great English writers, first Shakespeare and Scott, and later George Eliot, Mill, Spencer, and Ruskin.

For some years she was a teacher in a girls' school, and for twenty years she occupied the Chair of History of Civilisation in Sweden at the Popular University of Stockholm. She published no book until she had reached middle age, and the work we are about to discuss belongs to the author's fifties, like a host of the great masterpieces of philosophic and scientific thought in the past. She did not become conspicuous in Sweden until an old law against heresy was revived in order to send to prison some young men who had publicly argued about the bearings of Darwin's teaching upon human conduct and belief. "Henceforward," as Dr. Havelock Ellis tells us, "the conventionally respectable elements of Swedish society felt justified, according to the usual rule, in dealing out reckless and random abuse to the daring pioneer. She, on her side, retained her serenity, remaining a true woman, with much of the mother in her, and something of the child." But "it is easy to find estimable Swedes who are far from anxious to claim the honour which Ellen Key reflects on their land."

The prophetess is not without honour save in her own country. Her great fame has been made in Germany, where her name is a household word. Long ago Ellen Key parted company from very nearly all the avowed champions of woman, and proclaimed herself a "Feminist" of another

school. She is, indeed, the supreme champion of what the present writer has elsewhere defined and discussed as "Eugenic Feminism."

What we call the woman movement began (in modern times) in our own country and the eighteenth century, and was continued by such great nineteenth century writers as John Stuart Mill. The claim was for "woman's rights," by which were meant the same rights of citizenship, the same political place, as men. Many of these claims have already been granted, but Ellen Key and a few—very few—other champions of womanhood have seen that these demands do not cover all the ground, and therefore might lead to disaster.

Women who Feel that the "Woman's Rights" Movement Dethrones Motherhood

They ignore the claims of the race, they tend to dethrone motherhood, and they tend to masculinise women. Thus, in the excellent words of Dr. Havelock Ellis, a distinguished champion of eugenic feminism, "In their ardour for emancipation, women sometimes seemed anxious to be emancipated from their sex. Thus it was not enough to claim woman's place as a human being —especially in an age when man was regarded as the human being *par excellence* —but it also became necessary to claim woman's place in the world as a woman. That was not, as it might at first seem, a narrower but a wider claim. But on the merely human basis women were reduced to the level of competitive struggle with men, were allowed to bring no contribution of their own to the solution of common problems, and, worst of all, their supreme position in the world as mothers of the race was altogether ignored. So that the assertion of the essential rights of women as women meant at the same time the assertion of the rights of society and the race to the best that women had to give."

Woman's Right to be a Woman in the Interest of the Race to Come

Ellen Key is the champion of this new-old Feminism, which claims the right of woman to be a woman, not a man, and claims it in the double interest of herself and of mankind, present and to come. Love is at the core of the woman question and of the eugenic question, in her judgment; she sees them to be one, as they are, and her great book is the vindication of this view. She sternly opposes the great proportion of the feminist party which claims for woman the right to be a man, and she no less opposes those men who fancy, as ninety-nine Eugenists out of a hundred appear to fancy, that their task is only a man's task, to be achieved with the aid of woman's passive obedience, and love notwithstanding.

No wonder that the greater number of advocates of the "vote" in this country have either never heard of Ellen Key or despise her; no wonder that the dogmatic fanatics of every party cannot endure her. But in the book which we are about to study she shows that "eugenics and love, the social claims of the race, and the individual claims of the heart are not opposed, but identical." As Dr. Havelock Ellis says, in concluding his wise and lofty introduction, she resembles Miss Olive Schreiner as "the prophet of a movement which transcends merely isolated measures of reform;" and in this book of hers, even more than in any other, "we feel that we are in the inspiring presence of a woman whose personality is one of the chief moral forces of our time."

In a book which has not yet been published in this country, the present writer has tried to show the consequences and the promises for eugenics of the woman movement as Ellen Key advocates it. At one time it looked as if eugenics were destined for an early demise, from the failure of its leaders to value such forces as love and womanhood.

The Recognition Throughout the World of the Writings of Ellen Key

At the recent International Congress the only appointed speaker who directly advocated the claims of Love as a eugenic factor, or who mentioned Ellen Key, was the present writer, but it was very evident that a large measure of feeling in favour of that view existed, especially among the German, Scandinavian, and American delegates; and one consequence of the Congress was that many English Eugenists have begun to read "Love and Marriage." Only one other point need be insisted upon here. It is the main contention of the writer's book already alluded to. *No real progress in eugenics, no advance of man, can be attained by any devices, social or political, which do not enlist the finest of the world's women in the ranks of motherhood.* When Ellen Key, or anyone else, urges the claims of woman, and of the love which is in woman, for the sake of the race, as she does on many grounds, the student of pure heredity is bound to make his contribution to the argument.

We know definitely that there is no Salic Law in heredity. Transmission occurs

equally through both sexes. The name of the father alone may be inherited, but every one of us inherits equally, on the whole, from both parents. The characteristics of only the father may appear in any child, but the mother's may be what appear in that child's children. There is, no doubt, the peculiar and important fact which is called "sex-limited inheritance," so that women, in especial, may inherit and transmit various characteristics which they do not themselves display. This may lead us to suppose that women differ less than men do, as individuals, and therefore that selection of mothers is less important than selection of fathers, but in fact the importance of the two sexes, from the point of view of pure heredity, is equal. No fact or argument exists which gives any pre-eminence to either. As regards ante-natal nurture, to say nothing of maternal care after the child is born, woman is in a position of unique importance. We see once and for all, therefore, that a eugenics which did not take the quality of women as well as men into consideration would only be half eugenics, or rather less. These are the purely genetic and biological grounds which may be added to the psychological and more subtle basis of Ellen Key's great argument. Let us now try briefly to sum that argument, using her own words as far as possible.

The Loss of the World's Best Blood Through Celibacy and Virginity

What may be called the sex-morality of civilisation is changing, because our ideas of right and wrong, of good, better, and best, are changing. Virginity, lifelong celibacy, as the supreme ideals, reserved for the best and most exalted, for those who devote themselves to God, and leave the world for the "life of religion"—these, we see, involve the denial of a normal and valuable part of human nature, and tend to deprive mankind of the blood of many of the best of both sexes, as Galton long ago argued of mediæval celibacy. In these and many other respects our ideas and practice are evidently in a state of transition. The duty of all wise and well-meaning people is to direct that transmission rightly. But if we are to do so our first principles must be sound, our thought about them must be honest, and our exposition candid.

Ellen Key teaches, as the first of all principles, that personal love is the moral ground, and the sole moral ground, of all sex-relations. It is, therefore, of course, the moral ground of true marriage. Why should it have this place? any critic may ask —not improbably a Eugenist who wishes mankind at large to let him dictate its unions and partings. The reply is that not only does personal love "constitute in itself (independently of its mission to the race) a great asset in life, but it also raises or lowers the value of all else." It is the most valuable thing in the world, because it makes for the most life; and that is final for those who accept what Ellen Key calls the Religion of Life, as all Eugenists must. We profess the Religion of Life, which is to make the life of man as high and holy and healthy and happy and beautiful as can be.

The Claim that Personal Love Best Serves Life Present and Life to Come

This is the constant element of truth, indeed, in all the higher forms of religion, not least in that of which the Founder said: "I am come that ye might have life, and that ye might have it more abundantly." Many years ago, in the "Fortnightly Review," the present writer endeavoured, under the title of "The Survival-Value of Religion," to show how true religion is unconquerable, on pure Darwinian principles, because it makes for more and higher life.

Now, personal love, as Ellen Key understands it, serves life present and life to come supremely. Of course, she uses the word "love" to mean no common passion, but a complete expression of the community between two personalities. It has physiological and psychological elements; it is neither platonic nor merely sensual; it is one, in the words of George Sand, where "neither the soul betrays the senses nor the senses the soul." And this love must come first, as the cardinal moral ground of marriage, which, lacking that, can be made truly moral by nothing. In a word, "as a guiding principle of morality, the unity of marriage and love must be maintained." Let those who have hastily condemned Ellen Key for her teaching, or those who suppose that there is no need for any higher notions of sex-morality than most of us hold today, reflect duly upon this great principle which she enunciates.

Love the Truest of All the Tests of Character

No word has been or is more flagrantly or constantly abused than "love." We have seen what Ellen Key means by it, and here we may read her estimate of its depth and its relation to the essential personality of any one of us: "It may often be the case that a person's other manifestations are in a certain sense greater or less than himself, but his love, on the other hand, will in a

thousand cases to one be his inmost self. Great or mean, rich or poor, pure or impure, as he is in that, so will one also find him in the other important relations of life. Of all summary characteristics of a person, therefore, none is more sure than this—that, as a man has loved, so he is." Where others have spoken and written, usually with false and wicked intent, of "free love," which means, as Ellen Key says, "freedom for any sort of love," she speaks of what she calls Love's Freedom, the supremacy and the right to autonomy of this most precious and vital fact of human life, a fact which, we insist, combines and contains the two constituents, physical and psychical, of our nature, and therefore concerns the Eugenist of every school, whatever his ideal of mankind.

Love will exercise its freedom in its right to privacy; when we realise what a sacred thing it is: "The brilliant wedding festival will soon come to be regarded as ridiculous, then unbecoming, and finally immoral. And—like other survivals of the time when marriage was the affair of the family—it has already begun to disappear, in the same degree as love has developed. Lovers are less and less inclined to tolerate a spying upon their finest feelings; they are increasingly anxious to rescue them from the prying fingers of society, of family, and of friends."

Personal Love the Selecting Power to Achieve Eugenics

We must pass over the rest of this chapter, but the concluding paragraph must be quoted, for its pure wisdom and courage.

"All preaching of morality to youth which does not at the same time condemn the state of society that favours immorality, but makes the realisation of youthful love an impossibility, is more than stupidity—it is a crime. So long as the present low rates of pay and uncertain conditions of employment continue, the blood of men will continue more and more to be corrupted, and that of women to be impoverished, while waiting for the marriage which might have given to society excellent children born of healthy and happy parents. So long as societies thus fatuously sacrifice their highest values will every other kind of social reform be nothing but a work of Penelope, of which the night will undo what the day has done."

Now we come to what is, from our point of view, the crucial chapter of Ellen Key's book. It is called "Love's Selection," and asserts that personal love is to make that selection whereby what we call eugenics is to be achieved. Here is the absolute parting of the ways between Ellen Key and all who believe in love, on the one hand, and most reputed Eugenists on the other. She freely recognises the need and value of law in regard to "the obvious duty of not transmitting serious diseases the hereditariness of which is already ascertained by science." In later chapters it will here be asserted that the utmost rigour of the law cannot be too rigorous for some of these cases. But for positive eugenics, for the encouragement of worthy parenthood, not law but educated love must rule and guide.

The Wisdom of Medical Advice Before Marriage, and Impossibility of Medical Permits

Medical advice and examination before marriage is a sensible and desirable recommendation, in Ellen Key's opinion, but she sees the difficulty of making marriage legally dependent upon such examination. The present writer is of the same opinion. As he argued in his contribution to the International Eugenics Congress, there is a world of difference, in principle and in practicability, between the marriage permits for which many Eugenists argue—and which take no account of the subsequent manifestations of human nature in those to whom they would be refused—and a system of marriage certificates, showing freedom from disease, certificates which an educated public may soon come to expect, when we teach prospective fathers-in-law to look as closely into a young suitor's book of health as into his bank-book. We shall come—we are rapidly coming—to an appreciation of the rightness and usefulness of such medical help, in averting many disasters and forewarning against many dangers; but that is so unlike and so far from a law that no marriage may take place without medical permission that those who loosely confound the two proposals can scarcely escape the charge of inexcusable carelessness.

The Habitual Mistake of Eugenists in Confounding Marriage and Parenthood

Ellen Key recognises the difference between marriage and parenthood; she believes that many people should rightly marry, because of their personal love and the enhancement of life which their marriage will bring them, who yet should not have children, on account of some transmissible taint. She declares that "such sacrifices occur even now more frequently than is supposed," and the present writer can testify to the truth of her assertion. Since

the number steadily increases of those wise and kind and loving people who sacrifice the joys of parenthood, in the interests of the future, while rightly enjoying each other's love, it becomes a mere stupidity on the part of Eugenists to demand marriage permits, and to speak habitually as if marriage and parenthood were synonymous. Certainly the Eugenist desires parenthood through marriage alone; but there are many beautiful and valuable childless marriages, childless on eugenic grounds, against which the Eugenist can utter no word that is not insolent. The proposal for marriage permits ignores such possibilities, and gratuitously assumes that every marriage must mean parenthood. It is this habitually muddled thinking that largely impedes the progress of eugenics, and arouses just and effective resentment; and for such thoughtless thinking the work of Ellen Key is the best antidote.

Life has ascended, and can ascend, as this great woman knows, but she declares that Love's selection can, and will, hasten the ascent as never before. No doubt "the choice of personal love at present appears often either to lack or to oppose" what we may call the eugenic instinct. But there is such an instinct. "No prohibition, but only all the impulses of her blood," hinder a woman of a high race from marrying a member of a low race. "The woman who is known to have epilepsy is excluded from marriage less by the law, in this case easily circumvented, than by the fact that no man wants her as wife. On the other hand, it is known that, under conditions favourable to the cultivation of the beauty and strength of the human body, this has in a great degree influenced the erotic selection of either sex—so far as they otherwise possessed freedom of choice. The law of inheritance, which makes it easy for the degenerate to contract marriage, and women's need of maintenance, have, on the other hand, falsified the instinct of the latter in this direction. The prevailing customs and ideas of morality have, as a rule, deprived future mothers of their full freedom of choice, and thus to a great extent neutralised the importance of womanly love's selection for the spiritual and bodily improvement of the race."


ELLEN KEY

Here Ellen Key repeats a formidable and unanswered argument, regarding the laws of (monetary) inheritance, which was first advanced, now many years ago, by Mr. Alfred Russel Wallace. She sees, as all fair-minded observers see, that if Love's selection were really given a fair chance, it would prove to be, on the whole, a most powerful eugenic agent, but we give it a very unfair chance in most cases, and then Eugenists turn upon it and discuss how it may be circumvented. That is a shallow view, however distinguished its advocates; and it is particularly inappropriate in those who constantly quote Charles Darwin, who taught us all, in his study of what he called "sexual selection," that even in the lower animals there are eugenic forces of the most effective kind, which act through the mutual attraction of the sexes. If that is true of them, in any degree, it is a thousandfold truer of mankind, under fair and natural conditions. Those are the conditions which Ellen Key wishes to establish, for the sake of the future ennoblement of mankind through Love's selection; and the present writer, for one, believes that this is the heart and soul and substance of the eugenic problem. But he has very few Eugenists with him, as the published reports of the recent congress will testify. It is, above all, in and for the highest type of Love's selection that what we have already discussed as eugenic education, or education for parenthood, must culminate; and that is why education for parenthood is something far more and higher than mere instruction of a mother regarding, say, the feeding of a baby. The first question is, *what man's* baby?

But let us return to Ellen Key, though,

indeed, no summary can do justice to this great chapter. She argues that we need a word of more extended meaning than Galton's "eugenics," a word which shall embody "the doctrine of love as a consciously creative art, instead of a blind instinct of procreation." She goes on to say that "Religion, poetry, art, and social custom have collaborated to elevate racial feeling into love. They ought now to collaborate again to make the racial feeling conscious in love. . . . Freedom for Love's selection, under conditions favourable to the race; limitation of the freedom, not of love, but of parenthood, when the conditions are unfavourable to the race—this is the line of life. . . . When the point of view of the ennobling of the race has penetrated the ethical ideas of mankind, the following may be described as immoral, with a force at present unsuspected: All parenthood without love; all irresponsible parenthood; all parenthood of immature or degenerate persons; all voluntary sterility of married persons fitted for the mission of the race; and, finally, all such manifestations of sexual life as involve violence or seduction, and entail unwillingness or incapacity to fulfil the mission of the race."

The Ideal—One Man for One Woman, One Woman for One Man

Ellen Key well knows how far ahead lies the Golden Age, but she sees and knows that it will dawn when, and only when, "Love's selection has finally made every man and woman well fitted to reproduce the race. Not till then can the desired ideal—one man for one woman, one woman for one man—universally include the best vital conditions, for the individual and for the race. And when we have come so far, the will of Love's choice may also be so delicately and firmly entwined with every fibre of the personality's physico-psychical material that a man will only be able to find, win, and keep a single woman, a woman a single man. Then it may be that many human beings will experience through Love's selection what is even now the fortune of a few—the highest enhancement of their individual personality, their highest form of life as members of the race, and their highest perception of eternal life."

Believing as she does in Love's marriage, of course Ellen Key believes in that nowadays very unfashionable thing the Home. She discusses it fully, together with all the proposed substitutes for it, and she sees clearly what a few wise people see everywhere—that, with all its faults and disadvantages, the home is better than State institutions for children. Anyone can make the obvious criticisms which Mr. Bernard Shaw expresses so wittily in his unceasing tirades against the home. It needs a deeper insight to write as Ellen Key writes at the conclusion of her argument.

Nothing Could Compensate for the Abolition of the Home

"But so long as homes, even the best ones, have these faults, institutions must exhibit the same results, since both will be formed of the same human material. The institutions, on the other hand, would not possess the advantages which in the case of homes outweigh the faults. These faults may be gradually diminished by a higher spiritual culture. But nothing could compensate for what mankind would lose by the abolition of the home. . . . When Nature formed the instinct of the race, woman remoulded it as love; when necessity made the dwelling, woman transformed it into the home. Her great contribution to culture is thus affection. . . . And Bethlehem will always be there, where a young mother kneels in prayer by her child's cradle."

We come now to more difficult and controversial questions, upon which public opinion in Scandinavia is very different from our own. The ideal method of eugenics is marriage and parenthood through Love and Love's selection. The problems of the law of marriage, therefore, have to be faced; and it need hardly be said that the conditions of divorce, or the termination of marriage, are part, an essential part, of this problem. Ellen Key believes with all her heart in monogamy, but, as she says, "with ever-growing seriousness the new conception of morality is affirmed: that the race does not exist for the sake of monogamy, but monogamy for the sake of the race."

Service to Mankind the True Test of all Institutions

Marriage and all its conditions are, in a word, to be judged by eugenics, or by the "Religion of Life," in terms of the service they perform for mankind. The problem for the upholders of monogamy—which exists in Christian countries with a shameful twin-sister called prostitution—is to discover what conditions will best preserve this ever-threatened institution in its reality as distinguished from its imitations. We have to remember that this noble and indispensable institution is often "degraded to the coarsest sexual habits, the

most shameless traffic, the most agonising soul-murders, the most inhuman cruelties, and the grossest infringements of liberty that any department of modern life can show." How shall we preserve and protect marriage by freeing it from these abuses, and making it what we have declared that every sex-relation ought to be—the fruit of personal love, and by personal love indispensably made a moral relation at all?

The problem here presented is one which every Eugenist is called upon to consider in this country. It will be well if we hold hard by our first principles; and the most useful service the writer can perform is simply to state those principles again in Ellen Key's words. As she says: "The only thing that a psychological thinker can demand is that love should not divide the personality in any phase of a human being's development, but should always be its true expression. The possibility of becoming a complete personality in and through love depends in half upon the pure and whole desire of the other to share in developing the common life. This makes words about the duty of life-long love as meaningless as a harangue about the duty of life-long health. . . . A person can therefore no more promise to love or not to love than he can promise to live long."

It would be unjust to the author to try to summarise her argument, but it leads very definitely towards, at any rate, such

"BETTER A DINNER OF HERBS WHERE LOVE IS THAN A STALLED OX WITH HATRED"
From the painting by Mr. G. W. Joy in the Oldham Art Gallery

modifications of our own divorce law as, it is understood, will be recommended by the Majority Report of our Royal Commission on the subject. Perhaps the strongest of the many arguments which she uses may be quoted, however, for it states the view of pure eugenics and the "Religion of Life" in a very clear form. She says: "It is evident to every thoughtful person that a real sexual morality is almost impossible without early marriage; for simply to refer the young to abstinence as the true solution of the problem is, as we have already maintained, a crime against the young and against the race, a crime which makes the primitive force of Nature, the fire of life, into a destructive element." But, she argues, if we are to have these indispensable early marriages, the law of divorce must be made more liberal than it is at present in this country, *in the interests* of marriage and of "Love's selection." And, at the same time, the absolutely sacred interests of children, where such there are, the children who are and have in them all mankind to come, must be safeguarded.

The Need of Living Worthily a Life Only Lived Once

No one sees this more seriously and convincingly than Ellen Key, nor can anyone be sterner in condemnation of irresponsible parenthood than this advocate of the true Freedom of true Love, as against the licence for any imitation of love which fools call "free love."

The final chapter, on the marriage law of the future, must yield us a few notable passages before we conclude: "When every life is regarded as an end in itself, since it can never be lived again, and must therefore be lived as completely and greatly as possible; when every personality is valued as an asset in life that has never existed before, and will never occur again, then also the erotic happiness or unhappiness of a human being will be treated as of greater importance, and not to himself alone. For it will be so also to the whole community—through the life and the work his happiness may give the race or his unhappiness deprive it of. For himself, as well as for others, the individual will then examine the right of renouncing happiness as conscientiously as he now submits to the duty of bearing unhappiness. The importance to children of their parents' life together will depend upon the kind of life it is, when it has been seen that when all is said the new generation has most to gain by love being always and everywhere set up as the condition of the highest worth of cohabitation. . . . A human material increasing in value and in capacity for development—this is what the earth will produce. . . . Those who believe in the perfectibility of mankind for and through love must, however, learn to reckon not in hundreds of years, and still less in tens, but in thousands."

The Two Camps into which Eugenists are Divided

Thus ends this remarkable book, or, rather, that portion of it which has been translated into English. Important and valuable in itself, it is more so as standing for a view of eugenics which is definitely opposed to the majority view, and is capable of no reconciliation with it. Whether or not the student refers himself to Ellen Key's chapters in detail, it is certainly necessary for him to determine the camp to which he shall belong. The military metaphor is not inapplicable, for actual conflict between the two views is inevitable. In certain highly important departments of what are here called negative and preventive eugenics, later to be discussed, there need be no opposition or controversy; our duty to the feeble-minded, for instance, is obvious to all who know anything of them. But in the whole realm of positive eugenics, which is concerned with parenthood on the part of worthy people, and its encouragement, we shall have to face a fight between the two views of eugenics, which we have called "Love notwithstanding" and "Love understanding," until the issue determines, on Darwinian principles, which has the greater survival value. The victory must go to the side on which human nature fights; and no one can question which that is.

The Enlargement of Vision by the Eugenics Congress

Meanwhile we may proceed to review that remarkable recent event the First International Eugenics Congress, in the hope, first, of discovering therein some guidance as to our future studies; and second, of learning what dangers beset us in the attempt to influence public opinion and legislation. No one could attend the congress without learning much, and having his vision of eugenics as an interest of the modern world greatly enlarged. Especially true is that of delegates from this country, where our work and vision have been too insular, and far too inclined to regard the promise of eugenics as a kind of special providence for the advantage of the British Empire, and its ruling classes in especial. But eugenics is for all mankind to come.

THE OUTERMOST PLANETS

The Plumbing of the Depths of Space to Find Slow-Moving Uranus and Neptune the Invisible

PROBLEMS OF THE PLANETARY SYSTEM

LEAVING behind us Saturn and his gorgeous retinue of rings and satellites, we must now proceed to the outer confines of the planetary system. Two planets circulating at vast distances from the sun, Uranus and Neptune, remain to be considered; and before leaving the subject of the planets we shall review certain general questions of their origin and history.

Saturn was the last of the planets known to the ancient world; we have precise observations of his position and movements from as far back as the third century before our era; and as a star of the first magnitude he must have been well known from the earliest times when men began to observe the sky. From that remote period until near the end of the eighteenth century, no new planet was discovered, although Uranus was all the time quite visible to clear eyesight. But, slowly as Saturn moves among the stars, Uranus moves far more slowly, taking over eighty-four years to complete his circuit of the sun. There was therefore no possibility that the wanderings of this distant world should be noticed, and his planetary nature discovered, until the science of astronomy had far advanced and become highly organised. Neptune, which so far as is known at present is the outermost planet of our system, is quite invisible to the unaided eye, and could never have been discovered except for the union of perfect astronomical instruments with the highest powers of mathematical reasoning. Uranus was found by accident, but the existence and position of Neptune were predicted, by exact calculations, before the planet had ever been seen.

William Herschel, a German organist at Bath, had fallen in love with the starry sky and the mysteries of the heavenly bodies, and spent all his means and years of labour in constructing with his own hands telescopes for his scientific studies. Never satisfied with the performances of his instruments, he made one after another of ever-increasing size and power, until he finally had a better telescope than any other in the world; but he was far from being a mere optician, and used every night, when the atmosphere was at all favourable, in the exploration of the heavens.

It was in March, 1781, that he discovered Uranus, which he took at first to be a comet. He was searching through the constellation of Gemini when he came upon a star which appeared to show a disc, being thus distinguished from fixed stars, which remain mere points of light even under the highest powers of the telescope. He found that this star could just be seen without a telescope, being of the brightness known as the sixth magnitude. Turning a higher power upon it, he noticed that its disc was enlarged in proportion. There was then no question that he had come upon some celestial body other than a fixed star.

Observing it on successive nights, he perceived that it changed its position among the stars. Still, however, it never occurred to him that this might be a planet. The number of the planets had been known from antiquity, and telescopes had been freely used for over a century and a half without the discovery of a new one. It was natural that Herschel should come to the conclusion that his moving star was a comet; and it was under that title that he published his account of its discovery.

The supposed comet was carefully followed by the principal observatories of Europe, and was found to move far otherwise than a comet might be expected to do. Instead of pursuing an extremely eccentric elliptical path, so as to pass comparatively near the sun, and then to plunge into remote distances of space, the new star gradually

revealed an apparently circular orbit, situated far outside the orbit of Saturn. As the months went on, this circular orbit became more certain, and Herschel was soon acclaimed as the discoverer of a new planet. He passed from obscurity into world-wide fame, and from George III., always a generous patron of the sciences, he received a pension for life, a home at Slough, near Windsor, and an official appointment as private astronomer to the King.

The Improved Namings of the Planet which Herschel Found

From its discoverer the new planet received the name of Georgium Sidus, the "George Star," in honour of his Royal patron; others called it Herschel, a name which it bore for many years; but the title Uranus, which was proposed soon after its discovery, received at last the sanction of the scientific world, as more suitable to the method on which the other planets had been named. In ancient mythology Uranus was father of Saturn and grandfather of Jupiter. After the planet's orbit had been fully calculated, it was found that Uranus had been seen many times before, and noted down on star-maps as a fixed star.

The mean distance of Jupiter from the sun is 483,000,000 miles; that of Saturn is 886,000,000 miles; and the mean distance of Uranus is very nearly 1,800,000,000 miles, or twice the distance of Saturn. The orbit of Uranus is fairly eccentric, so that the planet is 166,000,000 miles nearer to the sun at perihelion than it is at aphelion. It was last at perihelion—that is to say, the point in its orbit which is nearest to the sun—in 1883, and will return to the same position in 1967. The orbit is inclined to the plane of the ecliptic by less than one degree. Uranus moves in its orbit at a speed of about four and one-third miles in a second, and performs a complete circuit of the sun in eighty-four years and eight days. The earth passes between Uranus and the sun once in every three hundred and sixty-nine days and eight hours.

Doubts that Come with Extreme Distances in Space

The great distance of this planet from our earth makes measurements of it very doubtful, but its disc has a diameter of about four seconds, which would give it a real diameter of about thirty-two thousand miles, or four times the earth's diameter. Its volume is about sixty-four times that of the earth; but as the density of Uranus is exceedingly low, being only slightly more than that of water, its mass is only about fifteen times that of the earth.

The remarkable lightness of the materials of which Uranus is composed shows that this planet, like Jupiter and Saturn, is still in the vaporous condition. Its Polar flattening, due to the centrifugal force developed by its rotation on its own axis, is such that the equatorial diameter exceeds the Polar diameter by about one in twelve, a degree of compression which makes the globe obviously elliptical to the eye. The speed of its rotation has not been observed with any certainty, but its period is probably about ten hours. Uranus is tilted over in an excessive degree, though quite how much is still open to question.

Being more than nineteen times the distance of our earth from the sun, Uranus receives only one-three-hundred-and-sixty-eighth part of the light and heat which we receive. It is, however, a good reflector, owing to the fact that its visible surface consists of cloud. It has a very characteristic sea-green colour, due to the absorption of the red and orange components of sunlight by its enormously deep atmosphere, which extends far outside the visible surface of cloud.

The Moons of Uranus and the Peculiarity of Their Orbits

Uranus has four moons, of which the two inner, Ariel and Umbriel, were discovered by Lassell in 1851, and the two outer, Titania and Oberon, were discovered by Herschel in 1787. The orbits of these four moons are circular, and lie very close together. The remarkable peculiarity of the satellites of Uranus is that the plane of their orbits, instead of lying more or less in the plane of the planet's orbit, is almost vertical to that plane. The plane in which these satellites revolve is consequently seen from the earth sometimes edgewise and sometimes in full face. The plane of the orbits is tilted up to such a degree that it is a little past the vertical, and consequently the moons revolve in the retrograde direction.

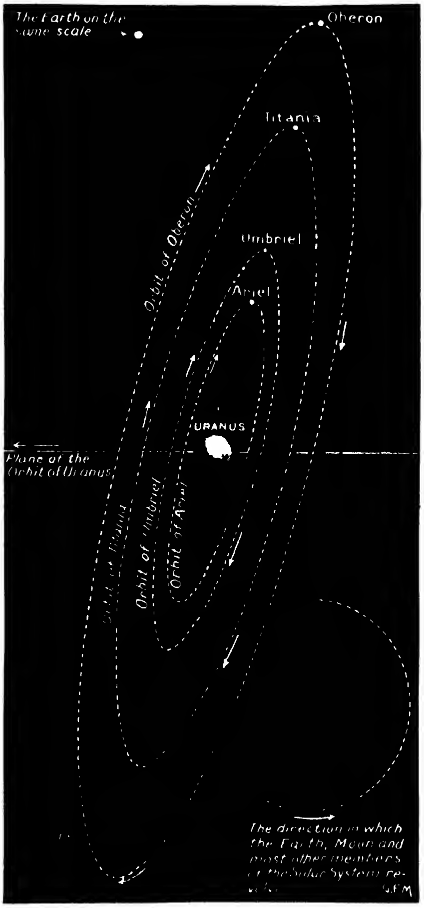
It is believed that these retrograde movements of revolution, found only in the very outermost parts of the solar system, are the remains of a retrograde rotation formerly common to all the bodies in the system.

The discovery of the planet Neptune in 1846, by purely mathematical reasoning based on the movements of Uranus, as explained and illustrated on page 772, was perhaps the most astonishing feat in the history of astronomy. The researches which are made by mankind in the vast distances

of the heavens have really a double interest. There is, on the one hand, the significance of the facts which are discovered, but there is also, on the other hand, the sporting interest of their discovery. This sporting interest would be acknowledged by every genuine scientific man. It is often suggested that the explorers of Nature work for the acquisition of fame, but there is little truth in any idea of that kind. Still less do they work for money. They are led on rather by a sporting interest in overcoming difficulties, as well as by admiration of the objects of their study.

Now, the difficulties and limitations of the observer are in no other study so great as in the science of astronomy. He is situated millions of miles away from the objects of his investigation; and keen eyes, a keen mind, and a few instruments, which are after all very simple, are all that he has to work with. The ardour and ingenuity which are able under these limitations to discover in the heavens an object which has not been seen at all, and to locate very nearly its exact position, are human achievements in harmony with the majesty of the planets themselves.

Part of the laborious routine of astronomy is the calculation beforehand of the positions which the several planets will occupy at definite dates and hours in succeeding months and years. Tables of these predicted planetary positions are published; and observers who are making nightly study of the sky become very soon aware of any discrepancy which may exist between these celestial time-tables and the actual position of any planet. So exact are the methods of calculation, and so regular are the planetary movements, that a discrepancy of this kind at once suggests some unknown cause which has not been allowed for in the calculation. So it was that the French astronomer Bouvard, who was at work in 1820 upon the time-tables of Jupiter, Saturn, and Uranus, finding that the two former kept to their predicted positions, but that Uranus departed from his by a very minute yet measurable distance, pronounced his opinion that the planet which then formed the limit of our system was disturbed in his orbit by the attraction of another planet yet more remote. Year after year the discrepancy increased. From a distance of twenty seconds in 1830, it became ninety seconds in 1840, and one hundred and twenty-eight seconds in 1846. The perturbations of Uranus in his orbit became the burning question of the astronomical world.



URANUS AND ITS SATELLITES

The orbits of the satellites are nearly circular, but they are shown here almost edgewise to indicate the tilt. This diagram shows the size of Uranus as compared with the relative distances of each satellite from it, and also the tilt of the whole system.

This was the opportunity of Le Verrier, a young French mathematician, and also of John Couch Adams, a young Cornishman, who had been Senior Wrangler in 1843, and in later life became professor of astronomy at Cambridge. The two men attacked the problem simultaneously, and solved it simultaneously, though Le Verrier's solution, which happened to be announced first to the scientific world, was also somewhat the more accurate of the two. It was in October, 1845, that Adams approached Sir George Airy, Astronomer-Royal at Greenwich Observatory, with his calculations of the position of the new planet, but it was not until July of the following year that Professor Challis, of Cambridge, began the search for it at Airy's request. Meanwhile, in June, Le Verrier's calculations were published. In September, 1846, Sir John Herschel, addressing the British Association, announced the prospect that another planet was on the eve of discovery. "We see it," he said, "as Columbus saw America from the shores of Spain. Its movements

have been felt trembling along the far-reaching line of our analysis, with a certainty hardly inferior to ocular demonstration."

In the same month Le Verrier wrote to Dr. Galle, of the Berlin Observatory, asking him to search for the new planet; and the German astronomer found it on September 23, the same night as that on which he received the letter. Neptune was found within one degree of the position which Le Verrier had predicted.

A Planet that was Seen, yet not Discovered as a Planet

On October 3, Sir John Herschel published a statement of the calculations which Adams had made, and claimed for him an equal share in the honour of this discovery. There followed a somewhat unworthy controversy between the partisans of the two astronomers, but it is now generally admitted that they were equally deserving.

As in the case of Uranus, it has since been ascertained that Neptune had been seen several times, and its position noted, before the discovery that it was a planet.

Neptune pursues a vast orbit, having a mean distance from the sun of 2,800,000,000 miles. This orbit, which is very slightly eccentric, is inclined to the plane of the ecliptic by less than two degrees. The planet moves at a speed of about three and one-third miles a second, and takes one hundred and sixty-four years to complete its circuit of the sun. Its apparent diameter is about two and two-thirds seconds, and its real diameter about thirty-five thousand miles. Its volume is about ninety times that of the earth, but its mass exceeds the mass of the earth by only about seventeen times. That is to say, like the other major planets, it has very low density, and has not yet cooled from the vaporous state. Like Uranus, which it resembles in several respects, Neptune shows a blue-green disc, invisible to the unaided eye, but plain enough through an ordinary field-glass. It is ranked according to its brilliancy as a star of the ninth magnitude.

Why the Earth Cannot be Seen from Neptune, though We See Neptune

As a reflector, it is inferior to Jupiter, Saturn, and Uranus. Owing to its great remoteness from the centre of our system, the sun would appear to Neptune no larger than Venus appears to us; and this distant planet receives only one-nine-hundredth part of the light and heat which we receive from the sun. From the surface of Neptune it would be impossible to see any of the planets within the orbit of Jupiter, and Jupiter himself would appear as a morning and evening star in close attendance on the diminished sun.

The planet has a profound atmosphere extending far outside its visible surface of cloud, and cutting off the red and orange constituents from the sunlight which it reflects. The spectroscope shows that there are elements in the atmosphere of Neptune as of Uranus, Saturn, and Jupiter, of which the nature is as yet unknown.

Although Neptune revolves round the sun in the direction in which the other planets proceed, its rotation about its own axis is believed to be retrograde; and the plane of its equator is inclined by about thirty-five degrees to the plane of its orbit. There are no clear markings on the surface of Neptune. The planet has only one satellite; or perhaps we should rather say that only one has as yet been discovered. This was first seen by Lassell immediately after the discovery of Neptune. It is of about the size of our moon; and its revolution round the planet is in the retrograde direction, in an orbit inclined by thirty-five degrees to the orbit of Neptune. Distant by about 223,000 miles from its planet, it makes a complete revolution in somewhat less than six days.

Why it is Unlikely that any more Planets will be Found

No quite certain answer can be given to the question whether there is any planet outside the orbit of Neptune. But most probably the answer will turn out to be in the negative. Neptune does not, so far appear to be disturbed to an appreciable degree in its orbit by the influence of any more remote body. On the other hand, it must be remembered that Neptune has not nearly performed the circuit of the sun since the year 1846. Not until the year 2010 will this distant planet have completed its prodigious circle. It has not yet been observed throughout half its course. It may yet approach and be influenced by some yet more slowly moving planet, of whose existence astronomy will then, for the first time, become aware. But any discovery of that kind becomes ever more unlikely. The sky has been searched, and the stars mapped and catalogued, with greatly increased minuteness and accuracy, since the middle of the nineteenth century. Moreover, within recent years photography has given its powerful aid, revealing hundreds of asteroids about the plane of the ecliptic, yet until now

showing no planet more remote than Neptune. And finally, many have considered, not without reason, that the complete breaking down of Bode's Law, in the distance of Neptune from the sun, may be taken as showing that with this planet we have reached the outermost confines of the solar system.

Certain general conclusions which have resulted from the study of the planets may here be noticed. In the first place, the materials of which the outer planets are composed appear to be on the whole lighter than those which enter into the composition of Mercury, Venus, the Earth, and Mars. This fact, and its significance, have already been referred to in an early chapter of this work. (See page 1258.) It was there shown that if we take the density of water as unity, the mean density of the four inner planets is 4·45, and the mean density of the four outer planets is only 1·25. It may be mentioned incidentally that our earth has greater density, so far as we are able to tell, than any other object in the solar system. Now, the much greater density of the four terrestrial planets, as compared with that of the four major planets, is largely due to the fact that the former have cooled to solidity, while the latter, on account of their great size, are still in a more or less sun-like condition—that is to say, are in all probability still vast masses of vapour, surrounded by visible surfaces of cloud.

Theories as to the Cause of the Differing Densities of Planets

But there is reason to believe that the great difference in density is also due in some degree to a difference in composition. That such a difference in composition is possible is shown by the difference in density between our moon and the Earth, for the former is considerably lighter in substance than the Earth, though it has certainly cooled further than our globe has done. Moreover, the vast atmospheres of Uranus and Neptune, in which free hydrogen, an extremely light gas, is known to play a large part, indicate that the lighter materials of our system may be present in larger proportion in its more distant than in its more central worlds. This is in conformity with the theory which holds that the nebula from which the solar system was evolved was formed by collision between two celestial bodies. In that case, the lighter substances set free would naturally coalesce in the exterior parts of the system, while the denser substances might be expected to preponderate towards the centre of the system.

In the second place, we must notice a very remarkable rhythm in the comparative dimensions of planets and of satellites, which has been pointed out by Professor Lowell. "Consider first," he says, "the way in which the several planets, as respects size, stand ordered in distance from the sun. Next to him is Mercury, the smallest of all the principal ones. Venus and the Earth follow, each larger than the last; then comes Mars, of distinctly less bulk, and so to the asteroids of almost none. After this the mass rises again to its maximum in Jupiter, and then subsequently falls through Saturn to Uranus and Neptune. Here we mark a more or less regular gradation between mass and position, a curve in which there are two ups and downs, the outer swell being much the larger, though the inner, too, is sufficiently pronounced."

Signs of Method in Star Systems that Cannot be Accounted for

This pattern, of an inner smaller curve, and an outer larger curve, is repeated in the system of satellites belonging to Jupiter, again in the Saturnian system, and finally in the system of Uranus. "The order in which the little and the big are placed with reference to their controlling orb is the same in the solar system, and in every one of its satellite families. Method here is unmistakable." There is unquestionably some profound principle at work in this uniform arrangement, but no one has yet succeeded in even guessing its nature.

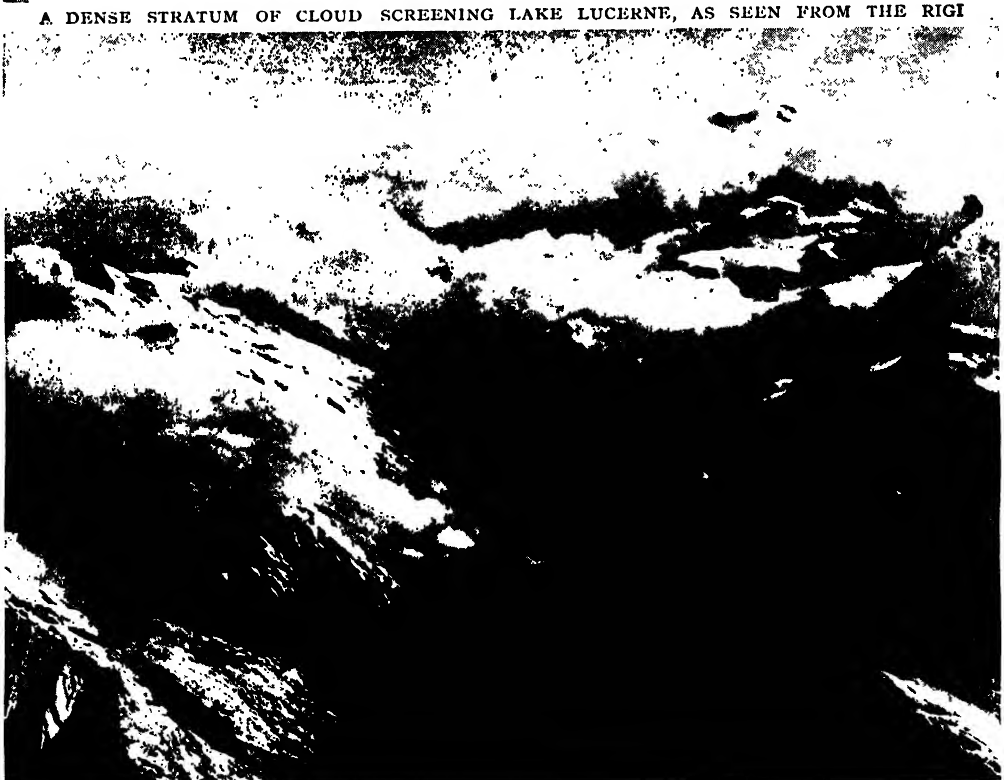
Finally, it can hardly be doubted that the retrograde movements of the outermost satellites in the systems of Jupiter and Saturn, the excessive tilt of Uranus, and the retrograde revolutions of its moons, and the same retrograde rotation of Neptune and revolution of its satellite—appearing as they do only at the very periphery of the solar system, and of these subordinate systems—afford evidence of great significance with regard to the development of the family of planets round the sun, and of moons around the planets.

A Nebular Hypothesis that May Explain the Place of the Planets

It is probable that the solar system originated in a two-armed spiral nebula, and that the several planets arose from knots on these arms. In their early stages they probably all rotated in the direction we call retrograde. The outermost planets and satellites have retained rotation in that direction, but in the case of all the others the axis has been turned over by tidal action so as to reverse the direction of the spin.

AN IMPERVIOUS BLANKET OF CLOUDS

A DENSE STRATUM OF CLOUD SCREENING LAKE LUCERNE, AS SEEN FROM THE RIGI



CLOUDS ENVELOPING A LOFTY ALPINE RANGE, AS SEEN FROM A BALLOON, 17,000 FEET UP

THE WEATHER MYSTERY

The Dependence of Climate on the Balance Between the Power of the Sun and the Shelter of the Atmosphere

AT THE COOLING POINT IN THE EARTH'S LIFE

ETYMOLOGICALLY the word "climate" implies inclination, for man long ago recognised the meteorological importance of the inclination of the sun, but the term has now a much more comprehensive significance. Wind, and rain, and dust, and humidity, and all meteorological factors relevant to man's comfort or health, are included in the conception. Humboldt defined climate as "all the changes in the atmosphere which sensibly affect one's physical condition," and Hann as "the sum total of the meteorological phenomena that characterise the average condition of the atmosphere at any one place on the earth's surface." It is, in fact, the *tout ensemble* of meteorological conditions considered from the double standpoint of geography and physiology. But a distinction must be drawn between weather and climate; the daily meteorological mean with respect to temperature, humidity, etc., of the atmosphere we must regard as weather, reserving the term "climate" for the seasonal or annual mean. We talk of bad weather if it rains from morning to night, and of good weather if there has been no rain for a week; we talk of a good climate when in any place all meteorological phenomena conspire on the average for the well-being of man; and we talk of a bad climate when on the average they conspire against man's comfort and health.

The mainspring of the climate is the mutual relationship between earth and sun. The orbit of the earth, the rotation of the earth, the inclination of the axes of the earth in relation to the sun, condition the climates of the world. Were the orbit of the earth doubled, its climates would be completely altered. Were it halved, we could not talk of climate at all. The heat of the sun is at the back of all meteorological phenomena; and the amount of heat which reaches the earth, and the distribution of the heat, depend on the earth's orbit, on the earth's inclination of its axes in its rotation, and on the revolution round the sun.

Life on earth, and the climates that favour life, are simply thermal episodes in the career of our planet. Between the heat of the sun and the absolute zero there are thousands of degrees. But the limits within which life obtains are only about 250°. We are rather inclined to claim for the earth the whole heat of the sun, but the total heat of the sun is terrific, and would not merely heat the earth, but even, 93,000,000 miles away, would reduce it to gases. Were we to clothe the sun in a mantle of ice two miles thick, in two hours and a quarter it would be entirely melted. Were we to lay a column of ice two and a quarter miles in diameter between the earth and the sun, and to focus upon it all the heat of the sun, in a single second it would be water, and in seven seconds more it would be water-vapour—the whole column of ice, 93,000,000 miles long, would be gone in a few seconds. We do not need all this heat—it would be fatal to life; and of the total radiant energy of the sun the earth receives less than 1-2000-millionth part—just the minute fraction necessary to ensure a climate favourable to life.

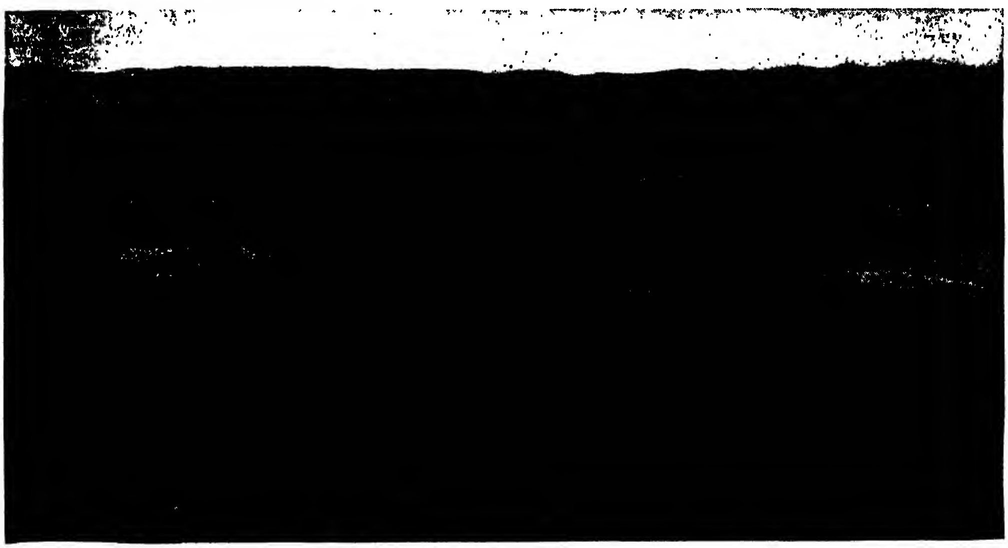
Let us look now at the climatic significance of the orbit of the earth. The orbit is not an exact circle; it is what is known as an ellipse; it is a circle flattened so that it has a longest diameter and a shortest diameter at right angles to each other, which divide it into equal parts. The ellipse is very nearly an exact circle, the long diameter being only ·014 per cent. longer than the short diameter. Such a small departure from a true circle is this that "if a circle three inches in diameter were drawn with a very sharp pencil, making

a line 1-5000th of an inch thick, it would represent the orbit correctly, the difference between the ellipse and the circle being concealed by the thickness of the line."

The orbit is not quite fixed; it varies in rhythmic fashion. For about two hundred and fifty thousand years it becomes gradually more and more spherical, and then for two hundred and fifty thousand years it becomes gradually more and more ellipsoidal. The sun is situated not quite at the centre of the orbit, but at a point on the longest diameter a short way from its middle; and as the orbit approximates a perfect circle, the sun approximates a central position; and as the orbit becomes more ellipsoidal, the sun becomes more eccentric. The eccentricity of the sun on the long diameter of the ellipse brings it nearer one end of the ellipse; and as the earth crosses the long diameter at this end, it is nearer the sun than in any other point of its orbit, while, as it crosses the long diameter at the opposite end, it is further away. The point of the orbit where the earth is nearest the sun is known as its perihelion, and the point where it is farthest away is known as its aphelion. Between perihelion and aphelion the earth gradually recedes from the sun; between aphelion and perihelion it gradually approaches the sun. At present the earth in aphelion is 94,500,000 miles from the sun, and in perihelion 91,250,000 miles from the sun; that is to say, that at its nearest point it is 3,250,000 miles nearer the sun than at its farthest point. But when the earth's orbit is most elliptical and the sun most eccentric, the difference between maximum and minimum distance may be as much as 14,568,200 miles. Maximum and minimum of eccentricity seem to occur at intervals of about 500,000 years.

Round this elliptical orbit, alternately approaching the sun and receding from it, rushes the earth at a rate of eighteen or nineteen miles a second. Now, it might be thought that differences in the distance of the sun must mean differences in the amount of heat received by the earth, and must therefore have important climatic consequences. One might think that when the earth is in aphelion it should be much colder than when it is in perihelion, and that when there is a maximum of eccentricity there should be a maximum of difference; and, indeed, on a supposition of this sort, attempts were made to explain the glacial periods.

But, as a matter of fact, the different distances of earth from the sun are not of great climatic importance. Winter in the Northern hemisphere occurs when the earth is in aphelion, and summer when the earth is in perihelion; and, as is well known, it is cooler on the top of high mountains than in the plains below. The factors that modify the climate and that mitigate or aggravate the heat of the sun are the atmosphere and the relative length of day and night. The daily differences between the heat of noon and even, of day and night,



LOOKING DOWN FROM DARJEELING ON THE WARM CLOUDS THAT THE MONSOONS BRING TO INDIA

are of the same nature as the differences between summer and winter, and as the main differences that distinguish climates. And these daily differences are a matter of the rotation of the earth and of the angle at which the sun's rays penetrate the atmosphere and fall upon the earth at different times of day.

Let us look now at both these matters—at the manner of rotation of the earth and of the penetration of the atmosphere by the sun's rays. First, as to the manner of rotation of the earth. It revolves once on its own axis in rather less than twenty-four hours. Were the axis of rotation perpendicular to the plane of revolution, every point on the earth's surface would have twelve hours day and twelve hours night, and the sun at noon would be day after day at the same height in the sky—*e.g.*, at the zenith over the equator, and 38° 70′ above the horizon at London. Every day, to every place, the sun would supply a certain quantum of heat; and though the amount would vary from place to place, it would not vary from day to day.

The heat, we say, would vary from place to place. Why should it vary? The same sun shines upon Timbuctoo and upon Klondyke—the same sun at practically the same distance. Why should the heat vary? It would vary simply because of the varying inclination of the sun's rays. Every day, as we know, it is hotter when the sun is high in the sky, and cooler as the sun sinks. The same principle would be at work here. The sun shining upon Timbuctoo would have a higher arch in the sky than the sun shining upon Klondyke. The higher the latitude, the lower the sun's arch and the less the sun's heat, but every place would have a constant temperature all the year round. Why, it may be asked, should the height of the sun in the sky, and the obliquity of the sun's rays, have such a marked effect on the temperature? The reason is twofold. Firstly, a ray of light falling vertically is spread over a smaller surface than the same ray falling obliquely, and therefore is more concentrated and has more heating power. A beam of light which, falling vertically, covers an area of a square inch, will cover two inches if it fall at an angle of 30°, and in the first case will have twice as much heating power per inch as in the second case. Secondly, the oblique rays have to pass through a greater thickness of atmosphere, and in their passage heat is absorbed and radiated back to space.

THE WINTER COLD THAT THE MISTRAL BRINGS TO FORT NATIONAL, IN NORTHERN ALGERIA

If, then, the earth rotated on an axis perpendicular to its plane of revolution, climate, as regards heat received from the sun, would be mainly a matter of latitude; and in each latitude there would be a constant quantum of heat received every day. But the matter is not so simple as that. The axis of the earth's rotation, as we know, is inclined to the plane of its revolution; and the result of this inclination is that the sun gradually in the course of the year moves northward across the equator

to latitude 23° 68′ north, and then appears to turn and move southward across the equator to latitude 23° 68′ south.

The effect of this movement is obviously to increase and decrease the height of the sun above the horizon, from day to day, in all places, in both hemispheres. From December 21, the so-called winter solstice, to June 20, the so-called summer solstice, the sun moves northward, and day by day the sun makes a larger, higher arch in the sky in all places in the Northern hemisphere, and a lower arch in the sky in all places in the Southern hemisphere; from June 20 to December 21 the sun moves southward, and day by day the sun makes a higher arch in the sky in all places in the Southern hemisphere, and a lower arch in the sky in all places in the Northern hemisphere. The result of this is, of course, that heat and daylight increase to a maximum and diminish to a minimum, from day to day, in each hemisphere alternately, and thus we have our seasons, and thus the climate in any place is not merely a matter of the latitude of the place, but a matter also of the varying latitude from day to day and from month to month of the sun itself. On March 21, the *vernal* or *spring equinox*, and on September 23, the autumnal equinox, the sun crosses the equator, and on these dates night and day are equal all the world over.

A STREET SCENE IN BISKRA, ONE OF THE HOTTEST SPOTS IN THE TEMPERATE ZONE

The main cause, accordingly, of the varying heat of the varying seasons of the earth is not the sun's varying distance from the earth, but the height the sun attains above the horizon of any place at any time; and the variation in this height from day to day due to the northward and southward march of the sun gives rise to the seasons—*e.g.*, a winter season with short days, and long nights, and oblique sun-rays, and a summer season with long days, and short nights, and more perpendicular sun-rays.

Seeing the radical relationship between sun-heat and climate, attempts were made long ago to divide climates into zones, according to the length of the longest day. Nearly eighteen hundred years ago Claudius Ptolemy, author of the "Ptolemaic System of the Universe, divided climates into zones in which the length of the longest day increased successively by half an hour between the equator and the Arctic Circle." The zones thus delimited varied greatly in extent, for the first zone embraced 8½ degrees of latitude and the twenty-fourth only 1-20th of a degree; and further, the division did not really give much information as to the general climate of any zone, for though the heat of the sun is distributed according to length of day, many local factors alter the ultimate result. Let us look at some of these local factors.

As we have already said, the diminution of heat consequent on the obliquity of the sun's rays is due partly to the impediment offered the rays by the atmosphere and its contents. How great the impediment is is shown in a great variety of interesting ways. Thus the very fact that light is white and that the sky is blue is due to atmospheric interception of the sun's rays. Were the rays of the sun not sifted by the dust in the atmosphere, sunlight would be blue and the sky itself black. The full physiological significance of the atmosphere filter we do not yet quite know, but we do know that a large percentage of the rays of the sun are obstructed by the atmosphere, and that without this obstruction the sun's rays

would be intolerably powerful. When the atmosphere is moist, and when clouds are formed, the hindrance to the passage of heat is much increased. There is no doubt at all that the selective absorption of the rays is of great climatic importance. And in different parts of the same zone this absorption necessarily varies to a great extent with the varying height above sea-level of any district or country.

The effect on the climate of diminished absorption of the sun's rays is not at all what we at first sight would expect. Since more sun-rays pass through the air and reach the earth, it would seem at first sight that this must mean a hotter climate. As a matter of fact, it means just the reverse, as a thousand snow-clad peaks inform us. How is this? The reason is simply that in considering the average temperature of any place we have to take into account not only the heat it is given, but its retentiveness of heat. Most of the rays which are absorbed by the atmosphere are absorbed by its lower, denser layers; and all these rays, when absorbed, are transformed into heat and warm the air-molecules. The warm air-molecules of the lower atmosphere, accordingly, act as a warm blanket, and keep the earth warm during the night; whereas the higher atmosphere, being less dense, retains less heat, and is a much less efficient blanket. It is true that the sun beats with more power upon the earth when a thinner layer of atmosphere intervenes. At an elevation of 11,000 feet, water can sometimes be boiled by putting it in a blackened bottle, and placing the bottle in the sun. But the point is just that the mountain tops are *not* blackened, and, though they may get an abundance of sunlight, they simply radiate it away again. It is not what a man gets but what a man keeps that makes him rich; and the high

A MARKET SCENE AT MURZUK, FEZZAN, WHERE 133·25 DEG. FAHR. HAS BEEN REGISTERED

places of the earth are spendthrift; they bank no heat; they live up to their income.

Not only the thinness and rarity of the upper atmosphere, but also its dryness, affects radiation of heat. The moister and cloudier the atmosphere, the more does it absorb heat radiated from the earth, and radiate it back again. After a warm, sunny day the night will probably be cool if cloudless, and warm if cloudy. The rapidity, indeed, with which heat can radiate away through dry air is amazing. Dr. Brown, in "Our Earth and Its Story," gives the following remarkable instances: "In the Sahara the skins of water are often frozen before daylight, though the heat of the preceding day was more than 70° above freezing-point. At Murzuk, the capital of Fezzan, in Northern Africa, the thermometer will sometimes show a temperature of 133° in the shade. Yet just before daybreak, Lyon and Rohlfs tell us, it will sometimes fall, during the month of December, 7° below the freezing-point, owing to the unchecked radiation from the heated soil. Snow also has been known to fall so heavily in the same region that in January, 1850, the flat roofs of Ghadames and Sokna, far in the desert south of Tripoli, fell in from its weight. In the Atacama Desert, the temperature of the ground is frequently 145° at mid-day, and even in winter the thermometer will register 98° in the shade, though four hours before it stood at 7°, this sudden change being, as in the cases mentioned, due to the rapid radiating going on in thi extremely dry climate." Very different indeed, are the climates of the Sahara an the Red Sea, yet both are in the sam latitudes; and very different would be th climate of Tripoli if those parts of it whic lie below sea-level were flooded with th Mediterranean. At high elevations the ai is necessarily dry, and its dryness, as wel as its rarity, favour the radiation of heat One half of the moisture in the air is belov 6000 feet, and only one tenth abov 20,000 feet. Above a certain height, accordingly, the air is always at freezing-point and at heights greater than nine miles i falls to a constant level of about − 70° Fah

But, besides the blanket, we must conside the baby; in other words, the soil as wel as the atmosphere, since soils have widel varying capacities for heat. It is ver generally considered that sandy soils ar healthy, because dry, and that clayey soils are unhealthy, because damp, but, on th other hand, it must be noted that claye soils are warmer than sandy soils. Th surface layer of sand is quickly heated, but sand is always mixed with considerable quantities of air, which is a very bad heat-conductor, and only the surface of the sand gets heated. The top of the sand, therefore, gets very hot, and may be heated up to 150° or 160° Fahr., but the heat is only skin deep, so to say, and soon radiates away. Clay, on the other hand, is a compact soil and a good conductor of heat, so that the heat spreads downwards more rapidly

THE MAIN STREET OF VERKHOYANSK, NOTED FOR ITS COLD CLIMATE

and to a much greater depth. And so, after a hot day, clay may give off heat from its underground stores for a long time, and this is especially the case if it be waterlogged. If the Sahara Desert had clayey, not sandy, soil, the days would be cooler and the nights much warmer. Again, if the ground is covered with grass, it will take in heat more slowly and give it out more slowly than if fallow.

The capacity, then, of the soil for heat must be allowed for. But most important in the final average of heat is the distribution of land and water. Soil can take up heat, the air can take up heat, but neither can compete with water in this respect. Water has a tremendous capacity for heat; it swallows up heat when the air is hotter than itself, and it gives it forth again when the more rapidly cooling air is cooler than itself. We all know how the sea gets steadily hotter through the summer, and cools only very slowly through the autumn and early winter. The amount of heat water can store during summer and give forth during winter is surprising.

The Baltic in summer takes up from twenty to thirty times as much heat as the land, and the North Sea takes up from thirty to forty times. Not only does water save up and then dispense heat in this way, but it also gives moisture to the air, which, in turn, reduces radiation. For these reasons island climates and sea-coast climates are usually equable climates, without great extremes of temperature.

But the sea warms not merely as a hot-bottle; it acts also as a system of hot-water heating, for its currents carry hot water and cold water all over the world. Britain and Norway, as we know, are warmed by sea water that comes in the Gulf Stream all the way from the Gulf of Mexico. Alaska and the Aleutian Islands are warmed by an equatorial current, the Kuro Sivo, which reaches them via Japan. On the other hand, the coast of Chili and Peru and the west coast of Patagonia are kept cool by Humboldt's Current, which comes from the Atlantic.

More important as carriers of heat even than the currents of the sea are the winds. We all know how the north-east wind in England is a cold wind and the south-west a warm wind, and we all know also how cool breezes may temper great heat; and it is hardly possible to consider heat apart from wind. The "Bora," blowing down from the Julian Alps, quickly turns summer into winter; the Mistral makes Algiers take to furs and fires. The Föhn visits the Alpine sport-centres in mid-winter, and the snow melts like butter on a frying-pan. The Sirocco withers whole vineyards in a moment. It is the Monsoons that make the seasons in India—indeed, the name means season; and were India not protected from north winds by the Himalayas its climate would be very different. It is the winds burdened with warm water-vapours that blow from the south-west that make the south of Ireland so mild and that give

ANDO, IN THE MILD LOFOTEN ISLANDS, IN THE SAME LATITUDE AS VERKHOYANSK

us a Cornish Riviera. Except, indeed, for the warm, moist, south-west wind, the climate of London would be like the climate of Greenland.

Because, then, of all these variable local factors which influence temperature, it is not possible to divide climate into zones even in respect of temperature. We can in a rough way distinguish between torrid or tropical zones, frigid or polar zones, and temperate zones, but the divisions will not be mutually exclusive, and any approximately true division-lines will not be straight. Still, this rough distinction is of some value.

Extremes of Temperature Noted Between Different Latitudes

We may divide off a torrid zone by two wavy lines which pass round the globe north and south of the equator through places with an average temperature of 68° Fahr. Within this torrid zone thus marked will be distributed rather irregularly most of the intolerably hot places of the world, such as Muscat, in the Persian Gulf, where the temperature may rise to 120° Fahr. and keep above 100° all night, so that "the sleepers during the night are watered, like plants, with a water-pot;" and such as Murzuk, where, as we have already mentioned, 133·25° Fahr. has been twice registered.

We may mark off a *temperate* zone south and north of the torrid zone, bounded north and south by lines passing through places with an average temperature of 32° Fahr.; and within this zone we shall find that extremes of heat and cold are rare, though Biskra may run up to 136° Fahr. occasionally, and even England may boast now and then of its 100° Fahr. in the shade. North and south of the temperate zones we may place the north and south frigid zones respectively; and within these zones we shall find most of the abnormally low temperatures of the world, such as the −73° Fahr. recorded by Nares, and the −62° Fahr. recorded by Parry.

Differences of Temperature Noted on the same Lines of Latitude

Modern meteorologists have extended the principle of this division. They have drawn numerous lines round the globe through places having the same mean annual temperature—the same mean summer, mean winter, mean monthly temperature, and so on. These lines are known as isotherms, and show the distribution of temperature in a very clear, interesting, diagrammatic way. Thus collated, we see that the warmest places on the globe lie on a line north of the equator, the reason for this being chiefly that there is more sea in the Southern hemisphere, and that sea, as we have said, mitigates temperatures. Thus collated, we see, too, that temperatures by no means follow lines of latitude. The Lofoten Islands and Verkhoyansk lie in the same latitude, yet their temperatures diverge to an extraordinary degree. The mean temperature of the Lofoten Islands is 40° Fahr.; at Verkhoyansk it is 0° Fahr. The mean January temperature of Verkhoyansk is −61° Fahr. below zero (and the record low temperature of −89° Fahr. has been recorded); the mean January temperature of the Lofoten Islands is about 32°—a difference of 93° Fahr. Again, in July, the north of Norway, the middle of England, the middle of Siberia, and Alaska all lie on the same isotherm of 60° Fahr.; while in January the Shetland Islands and the South of France are on the same isotherm of 40° Fahr. In January, some of the Northern American States are on the same isotherm as Iceland; in July, the same States are on the same isotherm as Algiers. In January, Lake Superior, in Canada, is on the same isotherm as Greenland; in July it is on the same isotherm as Central France.

The Important Effect on Climate of Moisture in the Air

So far we have spoken almost entirely of temperature, but temperature is only one feature, though perhaps the most important feature, of climate. From the physiological standpoint many other features of climate must be considered. Humidity, rain, wind, atmospheric pressure, have each physiological values, not only with reference to temperature, but on their own merits. Physiologically regarded, a mean annual temperature of 80° Fahr. on the Karoo, and 80° Fahr. in the Red Sea, mean very different things; and likewise a mean annual temperature of 40° at Davos, and a mean annual temperature of 40° in Newfoundland, mean very different things. Conduction, convection, evaporation, radiation of heat from the body, are all largely determined by the moisture in the air, and a temperature harmless in dry air may be fatal in air saturated with moisture.

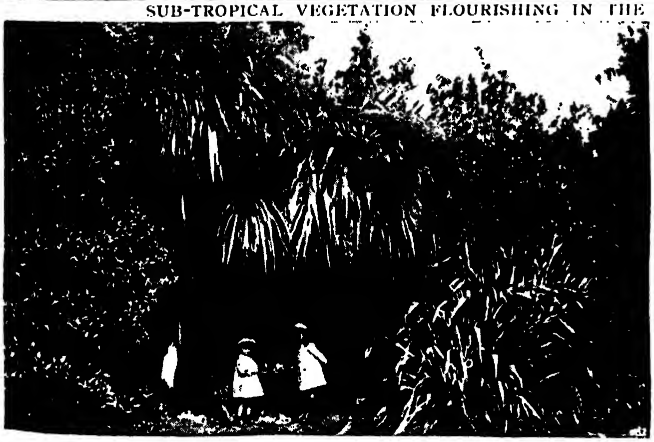
Dr. Harvey Sutton in experiments a few years ago proved that heat-apoplexy is always the result of combined heat and humidity, and Dr. Haldane showed that with the air temperature at 89° Fahr., and the wet bulb at 88° Fahr.—*i.e.*, in comparatively dry air—the body temperature remained the same after two and a quarter

GIFTS OF THE WEST WIND TO LYONESSE

ALOE IN BLOOM IN THE SCILLY ISLES

TREE-FERNS IN THE SCILLY ISLES

SUB-TROPICAL VEGETATION FLOURISHING IN THE CORNISH RIVIERA



DRACENAS IN A CORNISH GARDEN

BANANA-TREE AT FALMOUTH

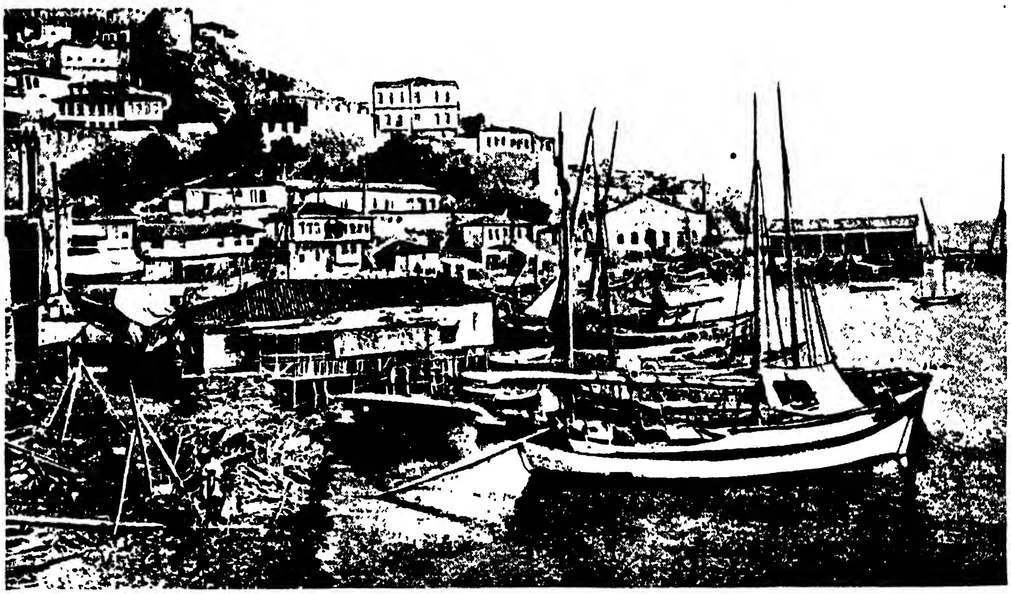
These photographs of scenery in Cornwall and the Scilly Isles, the ancient land of Lyonesse, are published by courtesy of the Great Western Railway Co.

hours. With the air temperature at 89° Fahr., and the wet bulb at 89° Fahr., on the other hand, the body temperature rose nearly 3° in the same time; and with the air temperature at 94° Fahr., and the wet bulb at 94° Fahr., the body temperature rose 4° in two hours. The subject, who was the same in each of the experiments, was stripped to the waist and resting. With moderately hard work and a wet bulb temperature of 87°, the temperature rose 4° in one hour.

All meteorological statistics admit the importance of humidity as a factor of climate, and give figures to show the relative humidity and absolute humidity of any place. It is a pity, however, that they do not simply give the readings of wet and dry bulb, which would really be more instructive from a physiological point of view. The average relative humidity in this country is 75 per cent; at Bloemfontein it is 58·5 per cent; in the heart of the Libyan Desert, 9 per cent. Humidity, then, must be considered, and also rain. It by no means follows that a heavy rainfall means a heavy mean annual humidity, but as a rule a rainy climate is a humid climate; and, quite apart from physiological considerations, a rainy climate is an uncomfortable climate.

Wind we have already mentioned as a carrier of heat and moisture, but, physiologically speaking, it has climatic value even apart from heat and cold, simply in its essential character as moving air. It is largely because of the movement of the air that seaside places are so bracing, and largely because of the stillness of the air that muggy weather is so depressing. Quite recently, physiologists have shown that if the air be kept in motion a much larger excess of carbon dioxide can be tolerated than if the air be still. On the other hand, Davos owes much of its value as a health resort to its freedom from wind in winter. The whole question, however, is mainly a physiological one; and here we must be content simply to point out that wind is a factor in climate that must not be neglected.

Air-pressure, too, is of climatic importance, not only in respect to the action of the atmosphere in hindering the passage of solar rays, but in respect to the direct effects of air-pressure on the respiratory and circulatory systems. Though, within considerable limits, alteration in atmospheric pressure can be easily met by the compensatory mechanisms of the body, yet health and vigour are affected by the matter of air-pressure; and the height of any place must be borne in mind in considering its climatic qualities.



MUSCAT ON THE PERSIAN GULF, A TORRID TOWN IN THE TORRID ZONE

Altogether, climate is a very complex conception, and a geographical division of climates is almost impossible, for climate is a function of geographical position only in a very broad way.

A very interesting side-question may be touched upon here: Is the climate of the earth stable, or is it subject to revolutionary changes? We know that in the Permian

Period, and at the end of the Pliocene Period, there were great Ice Ages. We know that the Eocene Period was probably much warmer than the present age. Are we in danger now of such climatic vicissitudes? We hear people often saying that the climate of England is altering, and certainly the tropical heat of last summer in England seemed to suggest a return to the Carboniferous Age. Is there any likelihood of violent climatic changes? Within the memory of man, local physical changes have produced local climatic changes; for instance, the cutting down of trees in Algeria has quite altered the Algerian climate. But for the last two thousand years, at least, the general climate of the world has been what it is now; and, so far as we can see, the same climate will go on for thousands of years, unless man himself finds some way of altering it. Nevertheless, seeing that there were once jungles and forests at the Poles, and that there was ice over the British Isles, and seeing, too, that we do not know the cause of these great climatic variations, it were well not to be too certain that the climate of the world as we now know it may not more or less suddenly undergo great and extensive alterations. The solar heat at present is not quite constant; it varies from time to time by about 5 per cent., and a greater solar variation might have big climatic consequences. Again, an accession to the atmosphere, and especially a great accession of carbon dioxide through a sudden exacerbation of volcanic action, would convert a great part of the temperate zone into a hothouse. Yet again, any great movement of the earth's crust, involving a great alteration in the relative proportions of sea and land, would put all the climates of the world at sixes and sevens, by altering the distribution of heat and the great sea-currents, and the amount of carbon dioxide in the atmosphere.

THE INFLUENCE OF THE WARM KURO SIVO CURRENT—FORT WRANGELL, IN ALASKA

In a word, so far as we see, there is no likelihood of any violent and universal change in the earth's climate, but it is often the unlikeliest things that happen; and we do know of possible changes that certainly would have cataclysmic climatic consequences. Even, however, if a cataclysmic climatic change did occur, it is probable that man would be able to adapt himself to that change, and to live through it, as he lived, in the distant past, through the changes of the glacial epoch.

THE BRINGER OF GOOD NEWS

The bringing of good news of the victory over pain is nobly suggested in this famous figure by Melozzo da Forli

MAN'S MOST DEADLY ENEMY

The War that is Being Waged Between Mankind and the Tubercle Bacillus

A GREAT DISCOVERER'S MISTAKE

Of all parasites whatever, the most deadly is the tubercle bacillus, or *bacillus tuberculosis*, which was discovered in 1882, in Berlin, by Robert Koch, the greatest of Pasteur's followers in the realm of pure bacteriology. For long there had been no doubt that such a microbe must exist, and Koch had indeed been searching for it for eleven years; but not until he devised a special technique, by which the microbe can be stained, and made visible, was he at last rewarded. Man is thus at last face to face with his greatest enemy in the living world, for this bacillus takes the life of about one-eighth of all mankind; and his first duty is to learn as much as possible about the foe he has to fight.

The facts are very remarkable, and they raise questions which we cannot answer as yet, but answers to which are necessary if we are ever to fulfil the prophecy of Pasteur, and make this parasitic disease disappear from the earth. In the expectoration from cases of consumption, in the degenerate substances of tuberculous joints, and elsewhere in the invaded body of man, we find this tiny fungus, a very slender rod. about one-twenty-four-thousandth of an inch in length. Its causal relation to the disease has long been proved, on the lines already discussed. But we find that, in many instances, animals suffer from tuberculosis which we have not experimentally induced. In fact, this is not a parasite of man alone. On the contrary, it can produce tuberculosis in apes, cattle, birds, fish, and many other animals, and we find it occurring in these creatures in all parts of the world.

Sometimes, as at the Zoological Gardens, we infect them; very often they pass on the infection to us—in milk, as a rule; in meat occasionally, or possibly. This adaptability and wide distribution of the bacillus constitute a formidable difficulty. It is almost, if not quite, as competent, hardy, widespread, pertinacious, an inhabitant of this planet as man himself. To deal with it radically can be no easy task. Microbes exist which apparently can live upon the body of man, and nowhere else. Their race is maintained in the world only by passage from man to man; and if this be arrested they must die out. Such would appear to be the case with the bacillus of leprosy, which is remarkably similar in microscopic appearance to the tubercle bacillus. Thus, if we isolate lepers, as our ancestors effectively did many centuries ago, there is an end of the disease. It attacks no other living creature, so far as we know.

But here we are faced with a parasite which attacks almost all the forms of animal life; and, if we are to win in the long struggle for existence between this parasite and our own species, we must learn the whole of its life-history. In the thirty years during which we have known this parasite, much has been learnt. With a fairly accurate idea of its distribution in the animal world, we know that it can be transferred from one animal to another, of the same or of another species. We know that it can live for a time in dust, dirt, and darkness. We know, also, that it varies a good deal according to the particular species in which we find it.

Thus man is really subject to two distinct forms of tuberculosis, of which we call one human and the other bovine. That is to say, in certain cases, the bacilli which we obtain from a human being suffering from tuberculosis belong to a type which is more commonly found in man, and is not normally found in bovine animals. This we call the human form of the bacillus; and we conclude that it has been derived

from another human being. But in other cases, which cannot be distinguished by the doctor as belonging to a different type, we find that the bacilli, when cultivated outside the body, show the characters which we associate with the bacilli usually obtained from bovine animals, and found, for instance, in about one-tenth of all the samples of milk supplied to our cities.

Such is the nature of the problem, as we have only very recently ascertained—so recently that it is very important to state the facts here at the very beginning of our discussion. Continuing his work upon the bacillus which he had discovered, Koch found not merely that it was responsible for similar kinds of disease in a variety of animals besides man, but also that its type varies in these different cases, and that, after long culture in the laboratory, on various media, one can still definitely declare one growth to be that of the "human" and another of the "bovine" bacillus. Naturally, the question arose as to the interchangeableness of these two types—the others, avian, piscine, etc., do not practically concern man. Koch made some experiments, and reached the conclusion that the *bovine bacillus is innocuous to man.*

Koch's Sensational Announcement of Man's Immunity to the Bovine Bacillus

This conclusion he announced, now more than a decade ago, before the International Congress on Tuberculosis, when it met in London; and of course the announcement, coming from the discoverer of the bacillus, and the greatest bacteriologist then living, made a great sensation.

Its practical importance was obvious. If man is immune to the bovine type of the tubercle bacillus, we need worry no more about the presence of bacilli of that type in tuberculous milk and meat. All our precautions regarding the slaughter of tuberculous cattle, the detection of tuberculous milk due to tuberculosis of the udder, or the pasteurisation or sterilisation, by other means, of suspected milk, are superfluous. All that department of the supposed prevention of tuberculosis may be ignored, and we must concentrate entirely upon other aspects of the problem. But Koch's conclusion was so surprising, it raised so many new problems—for instance, as to the source of the bacilli which so often invade the bowels of children—and it depended on so small a measure of evidence, that it could not possibly be accepted as final. A warning note was sounded, at the meeting in question, by Lord Lister, and a Royal Commission was very soon appointed to re-examine the whole question. This, it may be remarked, was an example of the right kind of Royal Commission. The object was not to shelve the question, but to gather together the best available men, and give them proper opportunities for ascertaining what so deeply concerns the well-being of the nation.

The Proof by a Royal Commission of Koch's Tragic Mistake

The Commission set to work, and after a period of several years its final conclusions were published. We now have the advantage of those conclusions, which are accepted everywhere, and we have to see the whole problem of tuberculosis in the light of them. In a word, Koch was wrong. He was a great genius in his way, but always a hasty one, and he had been tragically wrong, on a former occasion, with a "tuberculin" which was to cure consumption, but failed to do so. In the later case he was undoubtedly right in pointing to the difference between the two important types of tubercle bacillus. All that was valuable work, and the fruit of it will yet be gathered. The distinction he discovered is a real one; and we are definitely a step nearer the conquest of tuberculosis because Koch has enabled us to trace the origin of the infection in the various types of cases that we study, for plainly the first step towards arresting the infection is to know its origin. But Koch was unfortunately wrong in his assertion that man need not fear the bovine form of the tubercle bacillus. Our problem would be almost incalculably simpler if Koch had been right. It would probably be no more, in essence, than the problem of leprosy, which our ancestors solved.

The Gravity of the Problem of Infectious Animal Disease

We have to face the fact, however, that the bovine species, upon which we are so largely dependent, is a huge living reservoir of the tubercle bacillus, which is constantly passing from it to ourselves. Thus it follows, from the results definitely obtained by our Royal Commission, and no longer disputed anywhere, that even if we could discover and isolate every human being now infected with tuberculosis the disease would still continue—no doubt immensely reduced in amount, but widely prevalent nevertheless.

There is the gravity of the problem. In the case of leprosy, or of syphilis, or of many other diseases, one course of action,

the simple separation of the sick and the sound, will shortly abolish the disease, if it be thoroughly carried out; or such, at least, is the presumption, if the parasites in question do not come freshly into existence in any unknown ways. But here we require to protect the sound not merely from the sick of their own species, but also from the sick of another species which we cannot do without. And various obscure problems now face us. Let us for the present take it for granted that the bacillus may pass from one human being to another, or from, say, cows' milk to a human being. from tuberculosis. Once in *millions* of cases we find exceptions to this rule, but they are among the rarest of pathological curiosities, and need not concern us further. The rule is that, though the mother be rapidly dying of the disease, as many an expectant mother is today, the unborn infant is completely protected, thanks to the filtering action of the placenta, the organ by which it comes into relation with the maternal blood. Hence, though child-bearing almost invariably hastens the development of consumption, the practically invariable rule is that the infant is born free from any

DR. ROBERT KOCH EXPERIMENTING IN HIS LABORATORY

We then have it clearly understood that a human being may get the bacillus from one of two known sources, and not otherwise. That, of course, is most important and indispensable knowledge, not to be underrated. Our predecessors thought that consumption was a kind of degeneration of the tissues, probably of hereditary origin, pathetic, inevitable, uncontrollable. On the contrary, we believe that it is an infection derived from one or other of two known sources, and impossible of occurrence without that infection. We know, further, that the new-born infant is free

tubercle bacilli. For practical purposes the initial fact is that we all come into the world free from the infection which will ultimately kill one in eight of us. And that infection, as we have seen, can be definitely traced to one of two sources.

But the fact that there is a bovine source introduces the question of bovine infection. The calf is born, as we are, free from the tubercle bacillus, but somehow acquires the infection. If we could interfere with that infection we should strike at one of the two roots of human tuberculosis, and would be left with a relatively simple problem. The

trouble is that we do not yet know the life-history of the tubercle bacillus. We find it in cows and men, and in places which they have frequented, but we do not know its original source. The question of the source from which the cow derives it has not yet been seriously raised. We have simply taken it as the fact that the cow is liable to be infected, as we are, but we have not asked and answered for the cow the questions we have asked and answered for ourselves, nor do they look as if they could easily be answered. It can be readily proved that man gets the bacillus in cows' milk. No doubt calves are similarly infected by their mothers, and indeed good work has been done in separating calves from tuberculous cows, and thus obtaining herds free from tubercle. This Danish work is exactly parallel to the Swiss work in regard to the separation of infants from tuberculous parents. But the question arises whether such measures, rigorously carried out, would extirpate bovine tuberculosis, as segregation extirpated leprosy in man. It may be that they would not, because there may be some reservoir in Nature from which bovine animals can derive the bacillus. This is by no means improbable, though unfortunately we know as yet nothing about it.

The Possible Evolution of New Forms of Harmful Bacilli

Dr. Charlton Bastian and a few others have long warned men of science that they take too many things for granted regarding the bacteria. We are apt to label one kind "pathogenic" and another "non-pathogenic," and to assume that they have been so from the beginning, and will always be so. We talk a great deal about evolution, but we do not allow for evolution among the bacteria, though it must obtain there as it does everywhere else. It may be that the tubercle bacillus is a modification, or a descendant, or an adaptation, or a domestic form, so to say, of some other microbe, itself non-pathogenic, which has a wide distribution in Nature. Under favourable conditions, especially the close aggregation of human beings or bovine animals in dark, dirty, ill-ventilated places, it may be that some ubiquitous bacillus takes "pathogenic action," and becomes the tubercle bacillus we find in so many of the higher mammals under these conditions.

The species we call the tubercle bacillus must have had an origin somehow; and its origin can scarcely have been other than from a non-pathogenic form which found special opportunities for the extension and multiplication of its life in the bodies of certain animals under certain conditions. In the terminology which we have already observed, a saprophytic organism has become parasitic. We really require to search, therefore, for the natural ancestor of the tubercle bacillus, or the form, perhaps abundant, from which the tubercle bacillus can be derived under the conditions just described.

The Double Task of Rescuing Man and the Cow from Tubercle

Meanwhile, we see clearly that the problem of mastering tuberculosis cannot be achieved by man unless he at the same time achieves it for the bovine species. He must undertake this double task. The only alternative would be to abandon all use of the bovine animal as food, or, at any rate, of its milk. We can easily enough protect ourselves against tuberculous beef, and might not be compelled to abandon all beef, but could we give up cows' milk? This could only be done by having recourse to the milk of some other mammal not commonly affected by tuberculosis. Such an animal, it has been supposed, is the goat; and in recent years the proposal has been occasionally made by high authorities that the safest and most radical course would be to abandon cows' milk altogether and use goats' milk instead, but the immunity of goats from attack remains unproved, and does not warrant any such drastic proposal as the rejection of the cow. The present writer is of opinion that this is no solution. Man, and the ox, do not suffer from tuberculosis under conditions of open air and light, in which the tubercle bacillus cannot thrive; nor do we find tuberculosis in the anthropoid apes in their own forests.

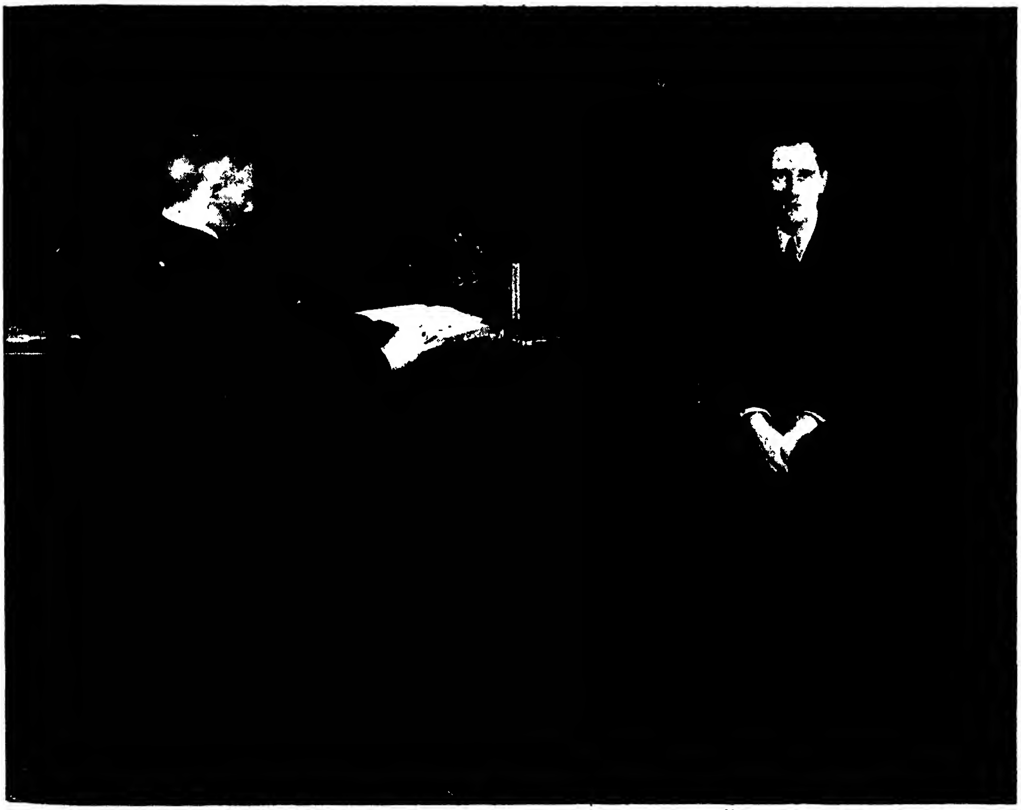
The Impossibility of Substituting the Goat for the Cow as a Milk Producer

But when man proceeds to live, or makes the cow or the ape live, under conditions which favour the bacillus, tuberculosis ensues. If we began to use goats' milk, the chances are at least very considerable that the enormous aggregation of goats which would be required, and the conditions under which they would be made to live, would quickly increase tuberculosis among them, whether because the resistance of the animals would be lowered, or because the bacillus can thrive, and perhaps takes its origin from other forms of life, under conditions of dirt and darkness. We already know that the goat is by no means immune from bacterial disease, for, as will later be described, what is known as

Malta fever or Mediterranean fever is due to a microbe which is distributed to man with the milk of infected goats. It is in the highest degree probable that, under the conditions which would soon be imposed if all our milk and dairy produce were to come from the goat, we should soon find it distributing the tubercle bacillus, as it now distributes the coccus of Malta fever.

If we wished to keep our goats free from the disease we should almost certainly find it necessary to provide them with hygienic conditions of life, and that is, in fact, what we may just as well proceed to do at once as to our procedure. Those facts are that mankind is constantly being infected from the cow, so that the complete segregation of infected human beings will not abolish the disease, and that there is no probability of any better state of things if man goes elsewhere for the milk and milk products which are absolutely necessary for him. He must therefore either use no uncooked cows' milk, nor any product of unsterilised milk, such as butter—which is, on the whole, an impossible or deplorable alternative—or *he must abolish bovine tuberculosis.*

That is the practical conclusion to which



THE WHITE SCOURGE, AS TYPIFIED IN "THE SENTENCE OF DEATH," BY THE HON. J. COLLIER

for our cows. No real alternative offers itself. Whether for the human or for the bovine species, the necessity is really the same—conditions of life must be provided in which the tubercle bacillus does not thrive. Though we do not know the natural source of the bacillus, we know a great deal about its mode of life. It likes dirt and darkness, and cannot face the sun. Unhygienic aggregations of the higher animals, in artificial dwellings which exclude the light, are its opportunity. Once, therefore, certain facts have been established, we have no choice

we are forced by the results of the Tuberculosis Commission. Tuberculosis is not a simple matter that can be dealt with simply. Even the liberal and persistent expenditure of unlimited sums of money will not abolish the disease, unless they are spent rightly. The nation might decide, from henceforth, to spend not a million but a hundred million pounds every year, or more if asked for, on human tuberculosis, and still would not abolish the disease. That cannot be done without the abolition of bovine tuberculosis, so long as we

continue to use cows' milk and its products. But, though as yet we do not understand the process of bovine infection, bovine tuberculosis can in effect be controlled, if we apply to it the same principles which are effective when applied to ourselves. The interests of the two species, bovine and human, must be regarded as one, and we must proceed with the bovine population as we mean to proceed with the human population.

The Need for Diagnosing Concealed Tuberculosis in the Cow

The Danes have shown that herds free from tuberculosis can be obtained. This is the first essential; as in the case of every other infection, the sick must be separated from the sound. The calves are born uninfected, as we ourselves are; and that clearly gives a starting-point. The adults must be sorted out; and here the importance of exact diagnosis is evident, as in the case of mankind. With such a disease as this, rough-and-ready methods are useless. They are not cheaper, even, for they fail to achieve the economic end. Anyone can detect advanced tuberculosis of the udder of the cow, but that is not enough. The Royal Commission ascertained the extremely unsatisfactory fact that the cow is liable to rid herself of tubercle bacilli by means of her milk, though the udder may be unaffected. Thus tuberculosis in any part of the cow's body may lead to the infection of the milk; and the necessity is imposed upon us of detecting concealed tuberculosis, which may perhaps be producing no obvious symptoms at all. Here we are greatly helped by Koch's researches, and the various forms of "tuberculin." Though these products of the tubercle bacillus were disappointing therapeutically, and require much improvement before they will do all we need for the cure of patients, they are very valuable in diagnosis.

Koch's Discoveries a Test, though not a Cure, for Tuberculosis

It is now possible, by means of the developments from Koch's work, to test a cow or a human being, and ascertain by the reaction whether the individual is suffering from tuberculosis or not. When we remember what proportion of samples of milk contain living tubercle bacilli, we shall not be surprised to learn what an enormous proportion of cows give a positive reaction when the tuberculin test is applied. But the fact has to be faced. The milk of such cows is not fit for human consumption, and such cows are a source of danger to healthy ones. Their calves should be removed from them directly they are born; and new herds must be composed of animals which are pronounced free from tubercle after the application of the tuberculin test.

Of course, this is a very serious and expensive business, but we can only reply that human tuberculosis is more serious and expensive still. There is more to follow. Supposing that we have at last obtained a stock that is free from tuberculosis, we still have to maintain it so. Many bacteriologists and veterinarians are inclined to assume that the stock can be maintained free from tubercle, provided that no tuberculous animals be introduced, just as a human stock can be kept free from leprosy on a similar condition. But this is far from being proved. As we have tried to insist, nothing is yet known as to the natural origin and natural habitat of the tubercle bacillus. At all times, some widely distributed saprophytic bacillus may be liable to undergo an evolution into what we call the tubercle bacillus, in certain conditions which we are only too apt to provide for cattle and for ourselves. If that be so, we can only maintain the freedom from tuberculosis of the stock we have obtained by providing it with hygienic conditions.

The Provision of Hygienic Conditions the Only Safeguard

In fact, that is the experience. The disease will somehow appear unless we take care, and that can only be done by keeping our stock in those conditions in which the tubercle bacillus cannot thrive. This is, of course, an expensive affair, and there is no end to it, but the only alternative—the use of goats' milk—would probably be found, as we have suggested, to involve just the same requirements.

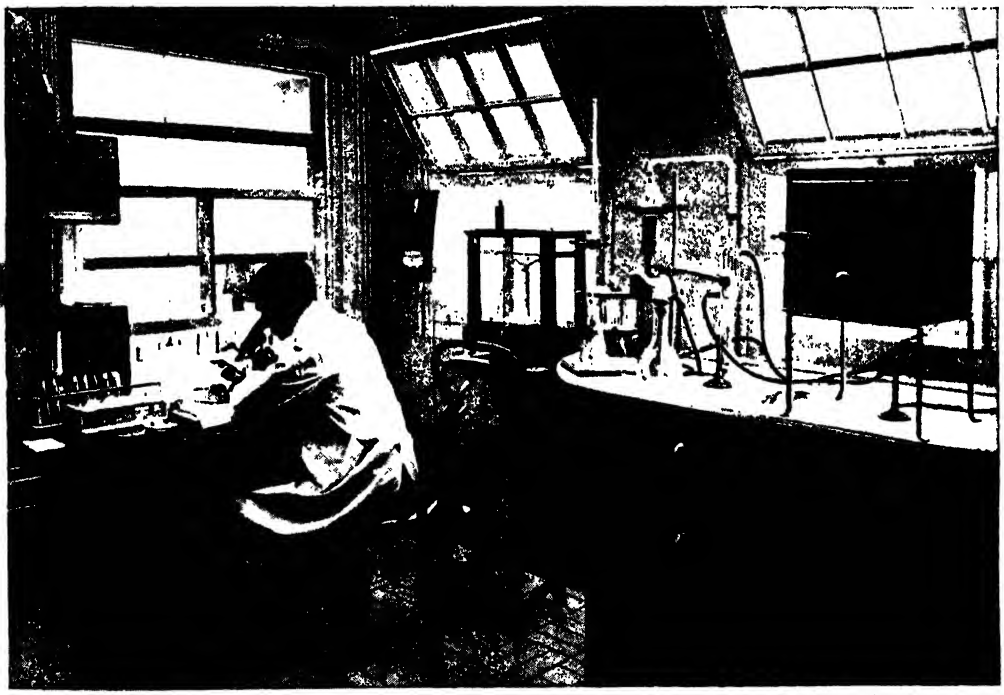
The principles of organic evolution, especially as laid down by Darwin, may afford us some guidance here. Should there not be a process of adaptation, dependent upon natural selection, by which we could breed a race of cattle, or of men, which should be immune to the tubercle bacillus? Then we need no longer trouble about the difficult task of exterminating a creature which may be hydra-headed, always liable to a fresh genesis under suitable conditions: and we might also save all the expense of sanitation and cleanliness and the supply of light, because our population would now be able to resist the tubercle bacillus, however abundantly it might continue to flourish under such conditions.

This is an argument which must be very carefully studied. There is no doubt that

the natural susceptibility of various animals and men to the inroads of this bacillus varies greatly. Just as Professor Biffen can construct a wheat which is immune to rust, why should not we be able somehow to produce races of cattle or men which are similarly immune to tuberculosis ? Or may it be that organic evolution, and the stern discipline of natural selection, with the destruction of the susceptible, must be invoked ? And if that be so, ought we not to encourage the spread of infection, and the conditions which favour it, so that, as soon as possible, the susceptible may be removed and an immune race produced ?

Such is the argument advanced, in the name of Darwinism, against modern measures for dealing with this disease. Its champions appeal to biological principles. They rightly point out, as we have tried to insist, that our modern study of disease must be biological; that this is simply a special case of the struggle for existence between two species; and they argue that it involves a selective action, whereby the most resistant will survive. So that all attempts to interfere with the disease will simply mean, in so far as they are successful, that we shall produce a race which will be more liable to it than if the susceptible had been killed off, and human susceptibility had disappeared with them.

The fact that real differences in susceptibility exist cannot be questioned. They are largely racial, and they do seem to correspond very largely to the argument of the Darwinians. Thus it has long been known that negroes, when brought into the cities of temperate climes, are extremely liable to tuberculosis. Their death-rate from this disease in the United States is enormous, and the same has been observed everywhere. This may be explained, we suppose, at first sight, on the ground that the negro is accustomed to the warm climate of the tropics, and that the cold of the temperate zones lowers his resistance to the tubercle bacillus which so much abounds in our cities. But a complementary observation has lately been made which disposes of this argument. The appalling susceptibility of the negro to tuberculosis is exactly matched by that of the Eskimo. Practically every Eskimo, without exception, who has been brought into the cities of the North Temperate Zone has sooner or later—but sooner, rather than later—succumbed to tuberculosis. We think of the Arctic regions as bitterly cold, and therefore liable to give one "colds" and bronchitis and consumption. But the fact is that the microbes of these maladies do not thrive there, and hence they are unknown. The Eskimo comes south from his frozen home,



A NECESSITY FOR EVERY DAIRY OF TODAY—THE LABORATORY FOR THE TESTING OF MILK

and the negro comes north from his torrid home, neither of them having been racially accustomed to tuberculosis, and they fall prompt victims.

Those are the facts. Here we neither reject nor accept the Darwinian interpretation of them, which is quite another question. It is obvious that members of these races, placed in a strange and complicated environment, and subjected to novel temptations, may lower their resistance, notably by alcoholism, to a degree which would render any racial theory of their susceptibility superfluous. For the moment we will not argue this question. But there are many more facts besides these.

The Extraordinary Immunity of the Jewish Race from Consumption

For instance, the Darwinian school may very reasonably point to the astonishing immunity of the Jews from consumption, even in the worst quarters of our cities, and may argue that this is the fruit of long ages of natural selection. The ancestors of modern Jews have been an urban people, confined to the ghetto, for very many generations. In other words, on this theory they have been rigorously exposed to stringent selection by the tubercle bacillus. If we could have access to records of the past, we should find that they suffered accordingly, but that the ancestral suffering has led to the formation of a race which is very nearly immune to this enemy. And the argument, then, is that only by similar means can the Gentile hope to defeat the same enemy.

Here, again, we place on record the fact, evidently important and, indeed, unique, but we do not accept this interpretation of it as final. We need only remind ourselves of the extreme temperance of the Jewish people in regard to alcohol, and the rigorous precautions which they take in regard to, at any rate, some forms of tuberculous infection. The Jew, who will touch none but "Kosher" meat, is at least safe in that respect.

A Type of People who can Kill the Bacillus for Themselves

As regards these facts of racial susceptibility to, or immunity from, tuberculosis, we can only say that they are very remarkable, and that we want to know a great deal more about them. Certainly they must have great lessons for us, which we shall some day be able to define exactly. But also within the limits of a race notable differences occur. When we survey the whole range of patients suffering from tuberculosis in an ordinary English town, we find that, broadly, two great types can be recognised. The number of intermediates will always predominate, and the gradation is continuous throughout, but patients from the opposite ends of the scale are unmistakably to be contrasted. The one type has acquired the disease owing to conditions which are, in the main, external and accidental. It is a chance that they are there at all, instead of being in the company of those who have never knowingly suffered from tuberculosis. They may have been exceptionally and persistently exposed to very virulent infection. They have been run down by measles, whooping cough, influenza, or some other infection, and, while in this exceptionally and unnaturally feeble state, the tubercle bacillus has taken hold of them. Or they have been overworked and underfed in conditions of darkness, dirt, foul air, and so forth.

Patients belonging to this type cannot be distinguished by looking at them. They are not predominantly dark or fair, so far as we know yet, nor of any other particular physical type. But we know them by the way in which they react to improved conditions and to treatment generally.

A Type of People who are Killed by the Bacillus

The mark of them is that, under anything like fair conditions, they put up a strong natural resistance. Under such conditions they recover, and that is the proof of their quality. But patients from the other end of the scale do not recover. They may or may not have been exposed to bad conditions, but when they are placed in good ones they do not respond. They are incapable of putting up an adequate resistance to the tubercle bacillus; and until the time comes when we can kill the bacillus for them and in them, by some special substance contrived for the purpose, such patients will die. They cannot kill the bacillus for themselves, but the other type of patients can.

Now, say the Darwinians, this is simply an illustration of well-known evolutionary principles. The race is undergoing evolution against this disease, just as the Jews, with their long residence in cities, have already undergone it. The differences between these two extreme types of persons are native, natural, transmissible. Therefore the only conceivable way of abolishing tuberculosis is by the natural way of abolishing persons liable to become tuberculous. They must be weeded out, together with the offspring, like themselves, whom they would otherwise have had, and so an immune race will

be produced. Here, again, we do our duty of placing on record the facts of contrast within the limits of a race, together with the facts of contrast between different races. But very much work of discrimination has yet to be done before the Darwinian argument can be accepted, and tuberculosis be relegated to the Eugenists as being their concern alone.

The fact must be accepted that, in adolescence, and even before it, clinical observers can detect two contrasted types of patient, with two very different prospects of recovery. But it by no means necessarily follows that these differences are natural. There is the factor of early nurture to consider; and even if the defective resistance be natural, we may find that it is *unnaturally* natural—due, perhaps, to the damage caused in the germ-plasm by parental tuberculosis (which is a blood-poisoning) or parental alcoholism. But until these possibilities have been excluded, and until we have definite evidence as to, for instance, the subsequent incidence of tuberculosis in breast-fed and not-breast-fed infants, we have no right to assume that the differences in resistance, which we observe in later life, depend upon what the Darwinians call "spontaneous variation," and can only be dealt with by allowing the tubercle bacillus to identify for us all those who cannot resist it, and then seeing to it that they produce no children.

What we require now is a rigorous analysis of the factors of the problem. The disease is an infection, and therefore we must learn all we can about the infective agent, its variations in virulence, the dosage of infection, the effect of repeated infection, the routes of infection, and so forth, it being assumed that every case of tuberculosis has involved efficient infection, which might have been prevented, as in the case of the highly susceptible Eskimo, who is quite free from the disease in his own country. Secondly, we have to study susceptibility; and from the point of view of practice and of prophecy, from the standpoint of the physician and of the biologist alike, we must undertake a piece of analysis for which, as the present writer has lately pointed out in the "British Journal of Tuberculosis," we are still waiting.

A MODERN SANATORIUM, WHERE SUNLIGHT AND FRESH AIR REPAIR THE RAVAGES OF A FELL DISEASE

We must somehow distinguish between genetic and somatic, inherited and acquired, susceptibility to this disease. If we find that the genetic factor is cardinal and preponderant, we must hand over the problem of tuberculosis to the Eugenists, for nothing we can do will solve it, short of the extermination of the bacillus, which is a large order, as we now see. But if and until the genetic factor in susceptibility is so appraised, we must deal with the somatic factor, the existence of which is indisputable; and we shall find that great things are already possible.

The orange bolet, Boletus versipellis

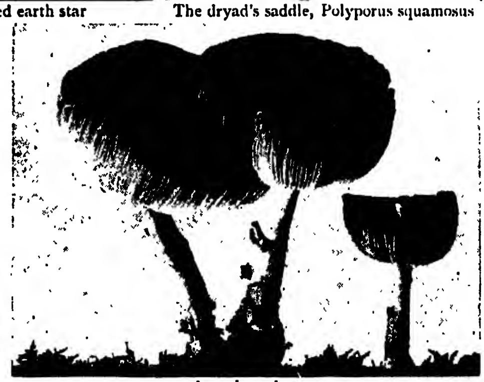
The chanterelle, Cantharellus tubæformis

Puff-ball, after bursting

The arched earth star

The dryad's saddle, Polyporus squamosus

The scarlet hood, Hygrophorus coccineus



Amanita spissa

Amanitopsis vaginata

Polystictus versicolor on a beech-tree

Cortinarius hinnuleus

THE FUNGI STEAL FROM OTHER PLANTS THE FOOD THEY CANNOT MANUFACTURE FOR THEMSELVES

BIDDEN & UNBIDDEN GUESTS

How the Friends of Plant Life are Attracted, and Its Enemies Repelled

DEVICES FOR SECURING FRUITFULNESS

In our last chapter we considered the important relationships between plants and insects and small birds, such as the humming-birds, in connection with the securing of cross-pollination for the benefit of the species. We saw that a very large number of insects might be truly regarded as the friends of plant life, and that even in the matter of pollination, not to mention the destruction of injurious insects, the birds, usually regarded by the gardener as his inveterate enemies, are, as a matter of fact, almost indispensable also. True it is, of course, that when various fruits of the succulent type are approaching ripeness, the birds, or some of them, do a certain amount, and possibly a considerable amount, of damage. But in estimating this it is frequently forgotten that if these same birds, or others, did not keep down the insect population at earlier periods of the year, there would probably be no fruit at all.

We realised the fact, then, in studying these relationships between plants and animals that some are useful to each other, while others are injurious; so that we might divide them, from the point of view of their mutual action, into friends and enemies. A more subtle division, perhaps, is that which, in the phrase of Kerner, groups the visitors of the insect creation of plants into the two categories of *bidden and unbidden* guests. These two terms convey the additional idea that in the one group there is a definite service to be rendered to the plant by their visitation, while at the same time they partake themselves of the plant's hospitality in the shape of the pollen and the nectar it offers as food. On the other hand, the mere mention of an unbidden guest suggests an idea of unwelcomeness and reproach, even if not actual danger, and further suggests to the mind that it would be advisable to take some precaution to prevent such visitors arriving.

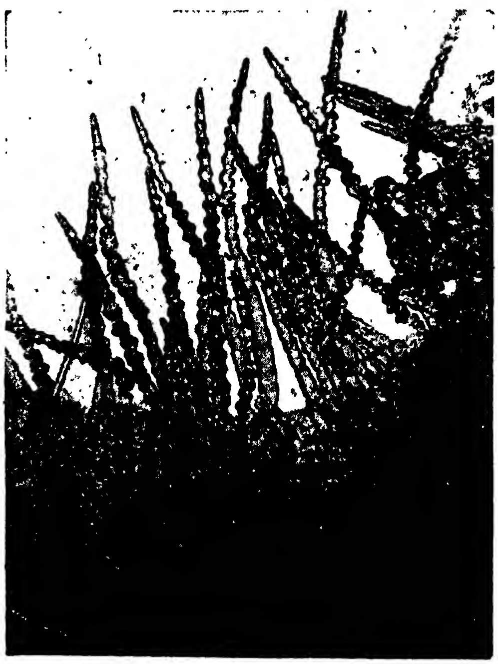
We have already considered in some detail what arrangements and attractions, or advertisements, as we call them, the flowers hold out, in many cases, to insects—arrangements which may be regarded as the invitations of the bidden guests. But we are here just upon the threshold of the division of the subject into friends and foes, and we must therefore note at this point what arrangements the plant makes for the reception of such visitors as come uninvited, whose visits can by no means be regarded as welcome, and whose presence is distinctly unprofitable, disadvantageous, and possibly dangerous.

Why should the plant require to protect itself against unbidden guests? What harm would they be likely to do? One may say that, broadly speaking, the visit to a plant of any animal, which interferes with the transfer of the pollen from one flower to another, may be placed in the category of the unbidden, unwelcome, and distinctly unprofitable. In this group are a great number of small wingless animals, which have to reach the position of the nectar and the pollen, if they reach it at all, by climbing over the various structures of the plant until they arrive at their destination. Should such a creature succeed in crawling over the plant and reaching the flower, and in doing so cover itself with pollen, it is quite obvious that on its return journey it is not at all likely to carry very much of the pollen with it by the time it reaches another flower, for which it could be used in pollination. Its method of progression is too laborious and tedious and risky, and the pollination is almost certain to be destroyed in transit.

But, on the other hand, the winged insects and the tiny little humming-birds are able to fly with amazing rapidity from

flower to flower, and garden to garden, collecting their food as they go, but also carrying with them such pollen as will pollinate each flower visited. As in this way the pollen is transferred with safety, rapidity, and precision, we cannot wonder that, so far as we can interpret the designs in plant life, the majority of the flowering plants adorn themselves with their most charming characters for the welcome of winged insects. These are of all agents the most perfect for cross-pollination. They are the welcome and the bidden guests.

Here, as in other spheres of life, however, all guests, even though invited, are not equally welcome or appreciated by their host. It is not any great satisfaction to the plant to be robbed of its pollen, unless the insect which is taking it to another flower can transfer some of it, at least, not merely with rapidity, but in such a precise manner that it will be certain of reaching the exact spot where it can fertilise—that is, the stigma on the next flower. There are flowers, such as the foxglove, for example, which are of such a size and shape that a very small winged insect can make its entry to the flower, and reach the nectar, and make its exit, without coming into any relationship sufficiently close as to cover itself with pollen. Quite obviously such a visitor, even though he be bidden in one sense, or, at any rate, attracted, must be regarded as far from welcome. So we come to the idea that it would be a wise precaution to take some steps which would prevent even bidden guests taking advantage of the invitation. Some arrangements must be made by which, if such guests are attracted by the same means which are required to attract others whose visits are really welcome, on arrival they shall be prevented at any rate from partaking in the meal. In other words, the nectar must be protected from unwelcome guests.



PROTECTIVE HAIRS ON THE FLOWER OF THE PANSY HIGHLY MAGNIFIED

Such arrangements there are in flowering plants in abundance, and mostly they take the form of some method of carefully guarding the entrance to the nectary, or the spot where the nectar lies. All sorts of structural obstacles are developed by plants for this purpose, but most of them have this in common—that, while they are quite strong enough, and effective enough, to prevent small insects forcing them apart, they are not of such size or strength as to interfere with the larger ones. A very small insect can crawl all over such an obstacle without being able to force its way into the nectar. He is the bidden but unwelcome guest, who is not invited to the supper. The larger insect, who is not only bidden — that is, attracted — but whose visit is welcome, because of the service rendered in the distribution of pollen, finds that the entrance to the supper-room, where the nectar is awaiting him, offers no obstacle to his proceeding.

Sometimes, however, these obstructive arrangements against smaller insect visitors have the further arrangement of diverting their path towards the anthers and the stigmas, with which they are almost forced to come in contact; and in this manner they do, even though unwillingly, contribute their share to the process of pollination.

The general arrangements made by plants to prevent flowers from being injured by useless visitors, that creep up from the soil, are sticky secretions on the foliage, impeding the passage of insects beyond; the position of the plant itself, as, for example, when surrounded by water; certain definite structures of a hairy or glandular nature on the stems; viscous secretions which occur on the flower-stalks; and the waxy layer which in many plants protects the flowers from small insects. All these, of course, are external to the vital organs

of the flower itself. Arrangements, however, also exist within the flower, and these are usually in the shape of hairs of some sort, arranged in very different ways, either in bundles or networks, and so forth. Sometimes the hairs entirely cover the nectary. Sometimes they close the mouth of the tube of the corolla; and finally, in this connection, the unbidden and unwelcome guests of flowers are frequently rendered harmless by the attitude which different portions of the plant flower assume to each other—that is to say, they may be bent, or arranged in such a way that the insects cannot crawl into the tubes which admit without difficulty the delicate proboscis of a useful butterfly.

But we must now come to closer quarters with these enemies and foes of plant life in general, because the subject of the damage done to plants and crops by other living creatures which attack them is one not only of great interest to the student of plant life, but is also one of immense practical importance to the gardener and the farmer. We are about to deal now, therefore, with the actual forms of life that either directly or insidiously attack our plants for the purpose of feeding upon their pollen and nectar, simply as a means towards their own existence—that is, because they are parasitic in their habits. A parasite in this connection may be defined as a species which lives either partly or entirely on or in the tissues of another, at whose expense it grows. There is no question here of any service rendered by way of recompense, such as the spreading of pollen already considered. We are therefore entering the realm of the causation of the various plant diseases; and such is the importance of the subject that we shall devote several of the succeeding chapters to it.

THE FLOWERS OF THE TOAD-FLAX, WHOSE PETALS ARE CLOSED SO THAT THEY CAN ONLY BE OPENED BY HUMBLE-BEES

The advances made in recent years in the study of the lower forms of plant life, and of the life-history of many small insects, have brought to light the fact that the great majority of the diseases of plants and crops are due either to lowly forms of vegetation or to the attacks of predacious insects. Of these two distinct causes, probably the more extensive damage is done, at any rate in connection with the farm and

the garden, by the lowly forms of vegetation grouped together under the name of fungi. Of these, an enormous number, exceeding 40,000 species, are known to science. That being the case, it is at once obvious that no one volume, not to mention a few brief chapters, could pretend to do more than draw attention to the general type of structure of these growths, their modes of action, and the most important examples of their influence. For that reason we may here describe, in the first place, the structure and mode of growth of a typical fungus; and that will introduce us to the terminology of the group we shall have to use. This we may follow with a description of some of the more important fungoid diseases affecting common and important plants. The various points to be detailed will be quite clearly understood if a little attention be paid to the illustrations that have reference to the fungi.

One striking thing at once attracts attention in connection with their structure, and that is that none of them possesses any of the green colouring matter, or chlorophyll, which, as we saw in our earlier studies, is a most important, and even essential, element in the building up of the food-stuffs in ordinary plants. Indeed, it is because of the absence of this chlorophyll, for one thing, that these lowly fungi are driven to the parasitic life by the adoption of which they make use for themselves of the food which has been elaborated in the ordinary green plants.

HOW A BEGONIA WARDS OFF CREEPING INSECTS
The petals of some begonias are covered with bristly hairs on their under sides, to prevent insects crawling up into the flowers. The upper surface is free, as shown in the larger petal.

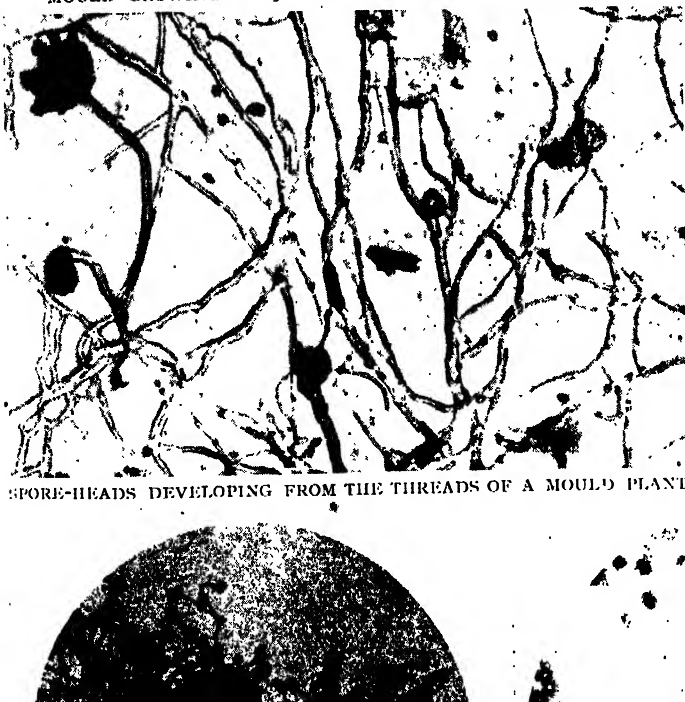
The entire mass, or body, of an ordinary fungus may be regarded as consisting of two principal portions—one which has for its function the obtaining of the nutrition of the fungus, and the other which is for one purpose alone—namely, for the purpose of reproduction. The first part, which looks after the food supply, is termed the *mycelium;* and this, in its turn, is found, when examined under the microscope, to consist of a great number of delicate threads or filaments, which are termed *hyphæ.* The hyphæ, then, constitute the mycelium. The second part of the fungus, that which is specialised for the purpose of reproduction, produces one or other kind of spores, to which we shall return in a moment. Still closer observation of each of the filaments, or hyphæ, shows that each one is a long, delicate tube, filled with clear protoplasm, in which there may be some nuclei and some drops of fat, but no grains of starch and no chlorophyll. Growth of the fungus takes place by each hypha elongating itself at its tip, and the hypha itself may be either undivided or it may be split up into portions, when it is termed *septate.* The simplest forms are non-septate. The whole mass of hyphæ, when looked at with the naked eye, suggests the appearance of threads of cotton-wool, no matter how large the mass itself may be. A little search among any decaying rubbish-heap will show plenty of examples of such fungus-like growths. In some species, however, the filaments are so closely woven that the appearance produced is that of a solid growth, almost like paper, or even leather.

The reproduction of these fungi takes place by means of spores, each spore being simply a single cell, produced by a special part of the fungus, and capable, when set free, of elongating into a filament. This, again, in its turn, produces other spores. The spores arise in two distinct ways—either by a simple separation of a portion of the parent protoplasm or by a sexual process of fertilisation. The sexually produced spores are of three different types, termed respectively *endospores*, *conidia*, and *oidia*, terms that must be remembered in order to understand the literature dealing with these important plants.

Endospores arise by a separation of a portion of protoplasm inside a filament,

THE GROWTH & PROPAGATION OF MOULDS

MOULD GROWING ON JAM AND SOME OF ITS SPORE-HEADS MAGNIFIED MORE HIGHLY



SPORE-HEADS DEVELOPING FROM THE THREADS OF A MOULD PLANT

THE SPORES SCATTERING

MOULD ON A FLOWER STALK AND SOME OF ITS SPORES MORE HIGHLY MAGNIFIED

When fungus spores alight on a suitable material they germinate, throwing out strands which permeate between the cells of their host, inducing their speedy decay. Afterwards the fungus threads throw up filaments bearing spore-heads, which provide for the spores being blown to other plants. These and other photographs illustrating these pages are by Mr. J. J. Ward.

the wall of the filament forming the wall of spore, and being called the *sporangium*. This is found at the end of a filament, and is generally round or oval in shape, but sometimes club-shaped.

The conidia are spores simply cut off at the end of a filament, and the filament which bears them is termed the *conidophore*. These may be produced in chains—one behind, another along the filament.

The oidia, or third form of spores, are produced by a filament becoming divided up into a number of small pieces, each of these segments being capable of producing a new individual.

The Power of Fungi to Grow Swiftly or to Lie Long in Wait

The illustrations in these chapters of various forms of moulds and fungi give excellent examples of these different methods of spore formation and their appearances.

Once the spores have been produced, the growth of new fungus plants from them is a matter of a very brief period, provided that the environment with regard to moisture and temperature is favourable. A few hours will produce a very distinct growth. Sometimes, however, the spores are capable of remaining dormant for a considerable time before actually germinating. When germination starts, a delicate tube begins to project from the spore, and very rapidly develops into a filament, or hypha, and ultimately a mycelium. Such is the very remarkable method of growth and reproduction in the fungi; and if the reader will, once for all, master the few technical terms above described, he will have no difficulty in following their life-history.

The Fungi that Live on Live Things and Those that Live on Dead Things

Since these fungi contain no chlorophyll, they are compelled to obtain their carbon food-stuffs from plants which already contain these foods. They therefore live their life either upon the bodies of dead plants and dead animals, in whose tissues the carbon compounds are of course plentiful, or else they deliberately attack the tissues of the living bodies of plants or animals, from whom they steal the food they require, and produce, as they do so, one or other kind of disease or infection. Those which live upon the bodies of dead plants or animals are termed *saprophytes*. Those which invade the living tissues and produce disease are termed *parasites*.

This simple statement will show us at once that the saprophytes perform an immensely valuable service to the world in ridding it of the carcases of dead animals and the bodies of dead plants, which they break up into more simple substances, rendering them available once more as plant food in a manner we studied in an earlier chapter. Some of them, however, may be regarded as plant enemies, or, at any rate, nuisances, in various ways, because they do not limit their action to substances whose removal is desirable, but grow when and where they get a chance. So we have the saprophytes producing the mould on the jam, or on bread, or in cheese, and, more seriously, in dead wood which is required for use as timber, but when thus affected is said to have the dry-rot. There is no hard and fast line between the saprophytes and the parasites. Some are entirely parasitic, while some may be saprophytes at one time and parasites at another.

A parasite which grows its mycelium on the outside of its host is termed *epiphytic* – that is, growing upon its host; whilst if it grow by penetration into the internal tissues, in which the mycelium is found, it is termed *endophytic*.

How Parasites Break Their Way Into Plants

The epiphytes simply absorb their food from the superficial layers of the plant on which they are growing by suckers, or even by a simple process of osmosis.

The spores of these fungi, which are produced in countless myriads, are distributed by various agents, but more particularly by the wind. They gain their actual entrance into the tissues of the plants either by penetrating through the stomata of the leaves or by dissolving a part of the wall of the leaf of the plant. Quite a number, too, gain entrance through the abrasions or wounds produced on plants that have sustained some injury, such as the breaking of a branch, or a pruning wound, or any other damage of that sort. Through such cracks the mycelium produced by the spore readily penetrates, and they are encouraged also to grow in and on such plants as contain considerable water and much sugar; and, as one may readily understand, the younger and therefore softer portions of the plant are much more readily penetrated by the mycelium of a fungus than is a hard layer of wood or bark.

The damage done to the host varies immensely in its nature and degree. The plant may be entirely killed, though this is not the usual result. The object of a parasite is not to kill its host, but to live

upon it. Killing it would, of course, stop the source of the supplies of food. The result, therefore, is, as a rule, merely injury more or less severe, indicated perhaps merely by a roughened, dark-coloured, abnormal appearance on a leaf, or an enlargement of some sort, such as one gets in a gall.

Various treatments may be adopted, and ought to be adopted, in connection with some of the plant diseases to be mentioned, but the following general principles should be carefully borne in mind with a view to the prevention of disease in plants, and in the ensuring of healthy conditions in the garden or farm. The minute character of the spores of these fungi should be kept in mind, because this means that it is so easy to carry them about from plant to plant, and from one place to another, unconsciously, and so spread their growth. Inasmuch as they live chiefly in and amongst dead and decaying matter, the inevitable refuse-heap to be found in one or other corner of the garden should not be allowed to remain long. Fortunately, the delicacy of their structures renders them easily killed, provided that they are on the surface; and therefore all such rubbish which harbours them should be burned as often as possible. One of the most important aids to a healthy garden is the keeping down of the weeds, because many of these fungi grow particularly on them; and since some of these disease-producers have special plants which they favour, note should be taken of the plants affected, and these be excluded from the area in question.

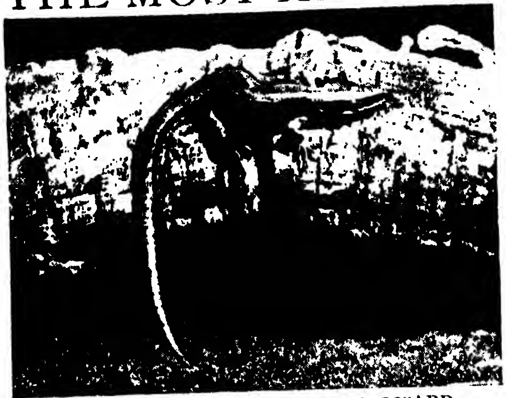
GALLS OF RHODITES EGLANTERIA

SPANGLE GALL ON AN OAK-LEAF

Lastly, in this connection, remember that it is the weak which go to the wall in plant life, as elsewhere, and therefore it is important to see that all the general conditions of plant hygiene, such as plenty of air, light, and sunshine, and adequate moisture, are attended to. Any conditions tending to overcrowd the plants or cause the ground to be too wet, or too hot, and so forth are simply encouragements to the attacks of moulds. Finally, directly any plant disease is observed to be present, deal with it at once. By so doing you may save an entire crop, or the infection may become extremely difficult to stamp out.

. Such are the general considerations which bear upon the growth, reproduction, and spread of the lower forms of fungi that are responsible for so many of the plant diseases. Amongst these diseases are many of extreme importance from an agricultural and economic point of view. As examples we need only mention the hop-mould, the mildew of the vine, and the potato disease, which are matters of vast financial interest. In our next chapter, therefore, we may take these, and some others. as types of the plant diseases produced by fungi.

THE MOST HARMLESS OF THE REPTILES

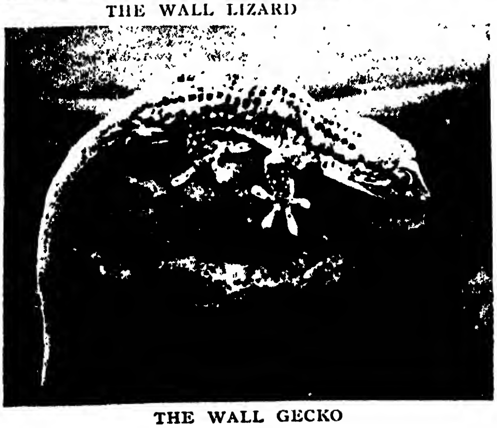


THE COMMON OR VIVIPAROUS LIZARD

THE SAND, OR AGILE, LIZARD

THE WALL LIZARD

A PAIR OF GREEN LIZARDS



THE WALL GECKO

THE EYED LIZARD

The photographs on these pages are by Messrs. C. R. Walter, L. Medland, C. G. Lane, W. P. Dando, S. Johnson, and others.

THE COMPANY OF LIZARDS

Small-Brained Survivals from Very Early Ages that are Now Again Multiplying on the Earth

UGLY BUT QUAINT, STOLID BUT QUICK

LIZARDS have a future, it is said. They are, remarks a high authority, apparently still on the increase in number and species, but certainly not in size. Our authority views, perhaps, possibilities rather than probabilities. He must write with a mental reservation postulating a world mainly "natural and unimproved," as the revenue authorities put it. There would be a future for many forms of animal life were it not that they need conditions incompatible with the prosperity and progress of the human race. Eighteen hundred species of lizards are scattered over the earth, and there is one in the sea. We have lizards which "fly," which, with adhesive feet, scale vertical walls; and we have lizards with no limbs at all; lizards with tails so fragile that, at the will of their owners, they snap like the limbs of the sea-dwelling brittle-star; lizards that are among the most baleful-looking of living creatures, yet are harmless; lizards which seem innocuous, yet are deadly in their attacks. But throughout the great group there is not a brain worth mentioning. Instinctive adaptability there is in abundance, very remarkable examples of it, too, but that is not enough.

The chamæleon, with his kaleidoscopic change of hues amid the trees, cannot hope to thrive as the advance of civilisation makes his trees more rare. He will disappear as the tuatera, or sphenodon, is disappearing. Geckos may make merry in Oriental houses for the time being, but there is hardly space or freedom enough for a new type of material modification to evolve. Time and space are against the group, or, at any rate, against such genera as have their homes within hail of the lands into which civilisation is daily thrusting. The deserts remain, and the waters. It will be there, if anywhere, that the future of the lizards must lie. And even the deserts may be reclaimed for man.

The whole brigade today, whatever the time to come may hold, is a very interesting one. There lives a lizard-like reptile which, though it cannot be considered as the ancestral form of the lizards, is undoubtedly descended from the great group of reptiles from which existing forms arose. This astonishing relic of the past—the sphenodon, or tuatera—has persisted since Permian days, the most primitive reptile on earth. As will be seen at pages 295-98, it is now rapidly vanishing before the advance of man. The sphenodon has stood still, so to speak, for millions of years; crocodiles, flying dragons, heloderms, and amphisbænas tell the tale of progress.

The tuatera is the sole existing representative of the "beaked lizards," yet is not a lizard. Neither, for that matter, is a chamæleon a lizard, but reference to both may be legitimately included in this chapter. As the tuatera has affinities with the birds no less than with tortoises, so the chamæleon, unlike all other lizard-like forms, has one point in common with a certain type of birds—climbers, and birds of the parrot tribe. Named indifferently the worm-tongued lizard and the four-handed lizard, this creature's resemblance to the parrots is indicated in the latter term.

The toes are divided into opposing branches. In the fore foot three toes are grouped to form the inner branch, and two form the outer; but in the hind limbs the order is reversed. This division of the toes gives the reptile a unique gripping power, and even the most casual observer is struck by the perfection of this modification. Another extraordinary feature of the chamæleon is its eye. This is one of the most remarkable organs exhibited by any terrestrial animal. The pineal eye, least vestigial

in the tuatera, which enabled ancient reptiles to see out of the top of the head, could have possessed no greater advantage than that afforded by the chamæleon's organ of vision. Here we have a large and protuberant eye, covered by a thick granular lid, perforated only by a minute aperture for the pupil. The two eyes can be moved independently of one another. One can look straight ahead, while the other scans the scene to rearward or on high. Why this doubling of the field of vision should accompany such excessively minute openings to the lids is a mystery.

So utterly lethargic a creature needs all the aids that can be afforded, for it is the very embodiment of sloth and deliberation. There can be no doubt that its slowness to avail itself of food, coupled, of course, with its power to undergo prolonged fasts, deceived impatient observers among the old naturalists into the belief, not yet extinct, that chamæleons exist on air. From Shakespeare to Shelley, all writers were wrong on this point. As a fact, of course, the reptile captures its insect prey by one of the most remarkable tongues yet fashioned. When shot forth to reach a fly or beetle, the tongue measures from seven to eight inches, and expands at the extremity into two parallel transverse flaps, coated with a gummy fluid by which the insect is secured. The extrusion and withdrawal of the tongue are so rapidly achieved that the eye cannot follow the movements, and has to call the camera to its aid. The celerity of the manœuvre is quite startling in a reptile which appears to think not twice, but two hundred times twice, before even setting one foot before another.

THE TUATERA, OR SPHENODON

This peculiarity as to the tongue does not, however, so sharply separate the chamæleon from other lowly types of life as some naturalists forgetfully suggest. A man need not travel farther than his own garden to see a very perfect extrusible tongue at work in frog or toad—animals of which a multitude of naturalists know absurdly little. Even the rapid flushing of changeful colour in the chamæleon is not a unique feature. Among lizards proper the same peculiarity is observable in the changeable lizards (*Calotes versicolor*), and, to a smaller extent, in Blandford's lizard, but not in the chamæleon lizard (*Gongocephalus chamæleontinus*), which is noted only for a certain external resemblance to the reptile from which it borrows its name. That resemblance extends to the tail, so far as appearance, but not function, is concerned, for the tail of the chamæleon is strongly prehensile, which the tail of the chamæleon lizard is not.

The great group of geckos, numbering over three hundred species, and widely distributed throughout the warmer parts of the globe, are a good example of the great diversity of habit and equipment by which the lizards are distinguished. The feet of the majority of them are equipped with adhesive discs, by means of which the little reptiles run up a wall or a window-pane, and scamper, head downwards, from a ceiling with the celerity and certainty of a fly. These are the species common in human habitations. Others restrict themselves to deserts, and in these many species lack the discs with which the feet of the others are furnished. Some make their dwelling amid rocks, some haunt bushes and low trees. One, the most remarkable of all, has developed the parachute resembling that of other so-called "flying" animals with which we have already dealt. The bark gecko, a reptile nine or ten inches in length, dwells on the lichen-covered bark of trees, and so closely resembles its background as to stand for one of the most famous examples of protective coloration. Interest centres, however, chiefly in the species which have become parasitic upon the homes of man.

Among Europeans the gecko is not wholly unwelcome, for it is a great snapper-up of insects. Anatomically it possesses distinct claims to notice, for the modification of the toes by which it makes its dazzling journeys across the ceiling is a

means to progress of a remarkable kind. Household geckos are not confined to one species, and various differences are to be noted in the feet of each. In some species the claws are withdrawn into sheaths at the extremities of the toes, while in others the claws emerge from the plates of the discs themselves, as in the talon-pierced sucker discs of the octopus. Another species, such as the lobe-footed, may possess no claws at all, while, again, others have the toes webbed as if for swimming, an art to which no gecko ever willingly inclines. Long as the geckos have haunted human dwellings, they have never ceased to be viewed with superstitious horror by their unwilling native hosts, who regard the reptile as venomous, as "the father of leprosy," and so powerful as to be able to injure a bar of solid steel with their teeth. Needless to say, this lizard is absolutely harmless and free from guile

A second great family is reached in the agama lizards, in which are grouped some of the most striking forms of lizard life. First of these are the flying dragons, as neat little creatures as ever bore a repellent title. At first sight the careless observer might think that it needs but an extension of the wing-like membrane to the legs and tail to furnish these little reptiles with true organs of flight resembling those of the bat. But a moment's examination shows how different is the plan before us. The bat has converted his hands into wings; here, however, it is the ribs that furnish support for the flight membrane. The last half-dozen or so of ribs are continued through and beyond the skin of the body, and are webbed together by a membrane which, when expanded, is one of the most effective of parachutes. Ribs and membrane fold down snugly like a fan when the lizard is at rest.

Endowed with this extra aid to flight, the small lizard, hiding amid the tree-tops, launches itself with confidence and accuracy into the air in pursuit of insects, and in the same manner passes with rapidity from tree to tree, illustrating before our eyes, as we think, the manner in which true flight originated. The "future" promised for the lizard tribe ought possibly to witness the evolution of another pterodactyle type from this genus, if only there were time and freedom to develop. Our little dragon, so called, with the crocodile as the "highest yet" of the reptiles, with the chamæleon as the most specialised in another direction, and with the tuatera to mark an approximate starting-point, constitutes as interesting and suggestive a group as can well be found.

A FIGHT BETWEEN THE BLUE-TONGUED LIZARD AND THE BROWN SNAKE OF AUSTRALIA

The typical agamas need not detain us, though there is a point in distribution to be noted. They are to be found on the borders of South-Eastern Europe, throughout the greater part of South-Eastern Asia,

and in the whole of Africa, but while they abound in the Punjab, Sind, and the Himalaya, they do not appear in India proper. One of the forty species, the agile agama, is distinguished for the speed of its movements, but none of them is slothful; and though they are to be found in large numbers in favourable positions, basking in the sun or hotly pursuing insect prey, so alert are they that their capture is a matter of considerable difficulty. Protective coloration is noticeable in many of the species, but they all appear to have inherited a notion that swiftness of departure is the safest course for a self-regarding agama to have in mind.


THE CHAMÆLEON

Another highly specialised agama is the Australian frilled lizard. Here, again, we have a phenomenal development of external membrane, but this springs not from the ribs, but from the covering of the neck and throat, and is supported by rods of cartilage, and opened and closed by special muscles. The purpose of this remarkable feature is, of course, not flight. It is simply a sort of mask—a mask which screens almost the entire body from view, and raised obviously as a menace to enemies. With his frill up and his jaws wide agape, this lizard is truly a formidable-looking little reptile, but he is perfectly harmless for all his terrifying show, and is only too thankful, when the danger is past, to rear himself upon his hind legs and waddle away with the gait of a bow-legged Blondin on a very treacherous tightrope. Another great impostor is the moloch, also an Australian product. The menacing attitude of the frilled lizard seems to declare, "I could an I would," but the appearance of the moloch boldly suggests "I can and I will." *Moloch horridus* is that redoubtable-looking lizard which the settlers have named the "thorny devil." Beginning at the head, which has an armament of curving horns and spines, the creature is positively crowded to the very tip of its tail with spines and bosses and defensive tubercles, a nightmare of defensive harness. Australia was unknown to the early writers of natural history, or to what appalling legends this really inoffensive pretender to puissance would have given rise! It is simply a harmless ant-eater, which adds a modicum of vegetable matter to its modest diet, and the whole armour, from which it gets its forbidding scientific name, is simply a relic, preserved in our own day, of the fashion in which the old-time eccentrics of the prime went forth to gain a living in security.


THE NAKED TOED LIZARD

The iguanas take, in the New World, the place of the agamas in the Old. They do more than that; for while practically every group of agamas has its duplicate in groups of iguanas, there are other groups of iguanas which have no parallel among the Old World brigade. It should be added that two genera of iguanas occur in Madagascar, a puzzling instance of discontinuous distribution, which is explained by the discovery of fossil iguanas in the upper Eocene deposits of France, where agamas seem never to have appeared. Many of the iguanas possess the power of more or less altering their hues; indeed, the anolis iguanas excel even the chamæleon in this respect. Some of them are as gorgeously coloured as butterflies, yet they contrive so wonderfully to blend their colours with the tone-scheme of their surroundings that only the brilliant yellow of the eyes betrays them, until they leap, with a cat-like spring, upon their insect quarry. In tropical America, where noxious insects swarm, the anolis is a welcome ally, and is readily tamed.

The far-famed basilisk is an iguana,

> . . . Whose pestilential breath
> Doth pierce firm marble, and whose baneful eye
> Wounds with a glance so that the soundest die.

Many of our ancient naturalists imagined another creature of the same name, but there can be no doubt that the bizarre appearance of the genuine lizard must have been a starting-point for many of the later legends that grew up about the harmless creature, which a child might handle with perfect safety. That is to say, the ancients imagined a fearsome beast which never existed in earth or sea; and the first man who knew the story, upon seeing this fantastic wonder of the New World, concluded that this must be the veritable basilisk, or cockatrice, of hideous reputation. But how its character for blasting with its breath the heath and all upon it could be reconciled with the luxuriant vegetation and ample population of tropical Central America, in which basilisks flourish, the early naturalists probably did not stay to consider. As a fact, the basilisk is essentially a very ordinary lizard, endowed with a frill to his tail no more alarming than that of our own frilled newt, and a similar membranous expansion covering the back, suggesting a reptile with the fin of a fish grafted upon it. The head, too, is peculiar in that from its rear springs a cartilaginous lobe. This lizard is entirely herbivorous, and, so far from seeking to inflict injury upon a living creature, it has no thought, upon discovery, but of flight. Its escape is effected, as a rule, by plunging into the water from an overhanging tree, which is its favourite place of rest.

THE MOLOCH

The Galapagos Islands possess two very interesting genera of iguanas, one terrestrial, the other marine. The former is a large reptile, sluggish, feeding on the leaves of a succulent cactus and the foliage of low-branching acacia, and making its home in burrows excavated in loose soil lying between fragments of lava, or, more commonly, in the soft sandstone-like tufa. The marine genus comprises still larger lizards, the greatest measuring as much as 4½ feet. They must have taken comparatively recently to life in the sea, for they go to it only for food, seaweed, and come ashore at the first suggestion of danger. The curious thing is that, when menaced on land, they do not take to the sea; when they can no longer run on land, they halt at the edge of the water; and though Darwin threw one out to sea again and again, it immediately returned each time to land. They have no natural enemies on terra firma, so they do not associate the thought of danger with life on dry land. Sharks, haunting inshore waters, are their chief cause of alarm, and they seek safety beyond the range of these monsters, where seas run not. When, therefore, a man, unrecognised till then as hostile, plays upon their fears, they cannot adapt themselves to the new situation, but cower down on shore, whither instinct impels them to resort whenever peril draws near.

THE FRILLED LIZARD

Among other notable iguanas must be mentioned the rhinoceros iguana, remarkable for a pair of small horns on the nose; and the horned iguanas, commonly, but wrongly, termed the horned toad of California. Here, again, a most impressive armament of spines has been developed, but the lizard is innocent of any attempt at aggression towards anything but the slow-moving insects of the barren sandy wastes in which it dwells. Of late, however, the horned iguana has come prominently into notice by reason of a totally unsuspected method of defence. By means not yet explained, it can at will eject jets of a fluid resembling blood either from the eyes or from glands thereabouts which have not yet been located. For some years a tradition to this effect existed, but hundreds of specimens were handled in vain by eager naturalists before the desired result was attained.

This is one of the strangest of defensive effects. There are many such, of course. The llama and certain African snakes spit:

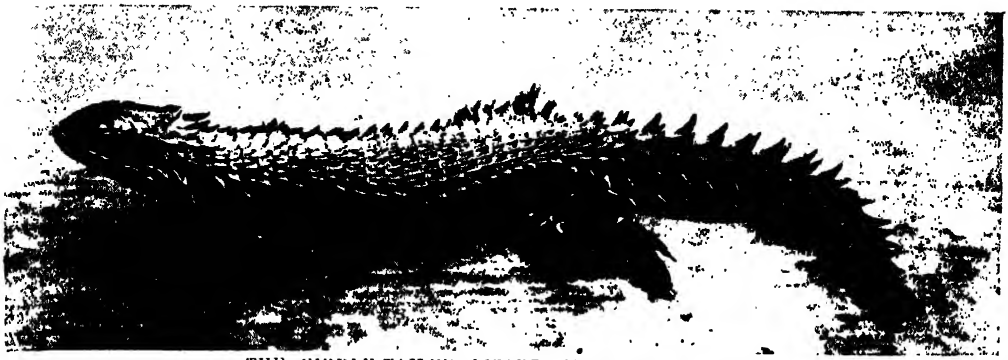
THE ANOLIS IGUANA

many sea-birds eject a noisome, oily fluid from their nostrils; the sea-lizard squirts a bead of fluid from each nostril; skunks and other animals secrete intolerable fluids; the bombardier beetle and certain caterpillars are proficient marksmen, with batteries charged with acid secretions. But the defensive action of the horned lizard is surely the most striking of all. There is no suggestion that physical ill results to the bombardee, but the action is so unexpected, and the method of effecting it so astonishing, that the net result must be calculated as highly probable to facilitate the escape of the lizard. And yet the latter is so well armed externally that such defence ought to be unnecessary. Here, perhaps, is the rudiment of a new plan of campaign evolved as an adjunct to armour, which in course of time mig be so developed as to render the cumbersor coat of mail unnecessary. That is the sc of thing a naturalist, given a million or of years, would have the joy of watching

THE BASILISK

Mention was made in the precedi chapter of certa lizards which a proximate in e ternal form to t snake tribe, a here we may nc one or two of the singular gener The elongated c lindrical body a absence of fc might be thoug a sufficient moc fication to adn of the whole bei grouped in o genus. That, ho ever, is not the case. Just as we fi venomous snakes evolved from varyi families of non-venomous reptiles, so we fi quite independent parallel development the lizards tending to one end in seve distinct genera. In the scale-footed lizar

THE SPINY-TAILED IGUANA

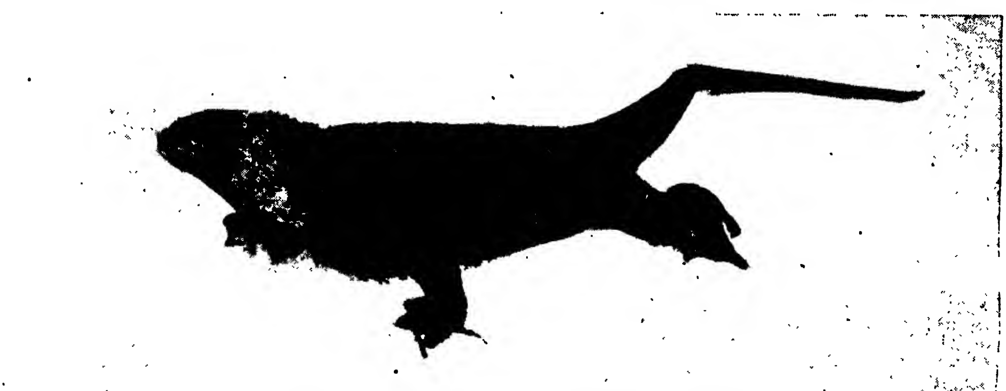


THE GIRDLE-TAILED LIZARD OF SOUTH AFRICA

of Australia and New Guinea the fore limbs have entirely disappeared, while the hind pair are now merely vestigial, barely perceptible in the female, scale-covered and functionless in the male, which is a reptile of twenty inches length. The girdle-tailed lizards include a South African genus, Chamæsaura, in which the fore limbs are missing, while the remainder are four-limbed and active climbers. Resembling in many respects the iguanas, the scale-tailed lizards are more nearly related to the slow-worms than are the scale-foots.

HORNED IGUANAS

There is no more absurd name in the whole range of nomenclature than that of slow-worm, or blind-worm, applied to the Anguidæ. They possess excellent sight, as the merest peep at their bright little eyes suggests. They are far from slow, but as active as any snakes of their size. The four limbs are entirely absent, so far as external sign is evidence, and they slough their skins whole in the manner common to all snakes. Some of the genera retain their limbs, some lay eggs, some—our own common slow-worm, for example—produce their young alive. The scheltopusiks, or glass-snakes, first thought to be limited to the wooded valleys of the steppes bordering the Volga, but now found to extend to other parts of Russia, to Hungary, Istria, Dalmatia, Asia Minor, Syria, Persia, Turkestan, Morocco, and even to North-Eastern India, Burma, and North America, serve to remind us how much the modern naturalist has had to learn to correct the fallacious teaching of even recent times. Like the slow-worm, it is commonly mistaken for a snake, and killed, which is



THE LAND IGUANA OF THE GALAPAGOS ISLANDS

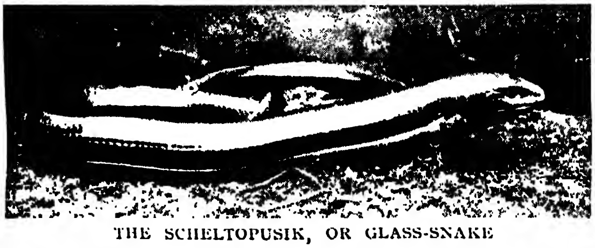
calamitous, for it is an unqualified friend of man, devouring mice, insects, and even vipers. The slow-worm, in turn, is equally to be desired in cultivated areas, for its food is entirely carnivorous, mainly slugs, insects, and worms. The approximation to the serpent form is here as striking as in any of the families already mentioned, but the attributes of the true lizards remain undiminished to the close observer. The eye has movable lids, which is characteristic of the lizard group. No matter how snakelike its form, if a reptile possess an eyelid to its name, it is not a snake, though we must be careful to remember that, as some lizards lack eyelids, we must not deem a lidless reptile a four-footed snake! One fact for which the slow-worm is entitled to undying fame is this: that it was in this reptile that the pineal eye was first discovered. Modern investigations lead to the decision that in the tuatera, at all events, the pineal eye should be read as "pineal eyes" that there were two of these organs of vision. Be that as it may, the one now visible to the left of the median line of the skull is quite functionless, and of the right there remains only the stalk. But the discovery of such a method of vision, and all the light that it throws upon ancient structure and methods of gaining a living, we owe to our little slow-worm.

THE SLOW-WORM

It is this reptile, again, which affords us the best known illustration of the ability of reptiles to snap and discard the tail. This is the part of the body by which they are most commonly caught, and it is, naturally, of immense advantage to them to be able to cut the cable, as it were, and depart, leaving only a relic in the hands of the would-be captor. The tail can be grown again in a modified form. The vertebræ cannot be renewed, neither can the spinal cord, but a cartilaginous support to a substitute for the original appendage is readily furnished; and at the present moment three pet slow-worms in the writer's possession are building tails with might and main.

It is perhaps a little unfortunate for the innocent little slow-worm that one of his nearest allies is the poisonous lizard of tropical Central America. There are two species of these lizards, forming a separate family named the Helodermatidæ, one being known as the Mexican and the second as the Arizona species. The latter is slightly the smaller, its length being restricted to some twenty inches. As in the snakes, the poison lizard has its venom contained in sacs at the base of the tooth, whence it travels by way of a groove in the fangs into the wound caused in the flesh of its victim. Although an attempt has been made to prove that the venom of the heloderm is not poisonous, the evidence is conclusive that its effects upon small animals are fatal, and decidedly harmful to human beings, though not, so far as is known, lethal.

THE POISONOUS ARIZONA LIZARD



THE SCHELTOPUSIK, OR GLASS-SNAKE

The largest of all the lizards are to be found in the monitors, of which, distributed

very generally throughout India, Africa, and Australia, there are some thirty living species. In the great age of reptiles, India had monitors twice as large as any now existing, while Australia rejoiced in a species measuring full thirty feet. While some of the species are to be found in deserts, the majority of them frequent well-wooded riversides or marshy ground, in which food and temporary shelter may be had in the waters. The large and powerful tail serves, as in the case of the crocodile, as a propeller in the water, and as a weapon of offence on land. Entirely

THE TEJU, OR TEGUEXIN

of the lizard tribe. Many species have retained only the merest vestiges of limbs, while the Mexican representative has lost the hind pair, and retained those in front. The peculiarity of these creatures is that they move equally well backwards or forwards, a circumstance correlated with their purely subterranean life.

The typical lizards, common to the whole of Europe, Africa, and great part of Asia, are represented by a couple of species in Great Britain. The whole family comprises seventeen genera. The skinks, again, are a numerous

THE STUMP-TAILED LIZARD

carnivorous, the monitors feed upon birds and their eggs, upon lizards, frogs, and what not, and have rendered the world good service by their unwearying search for the eggs of crocodiles, so preventing many a fell brood from coming to maturity.

America possesses, in the teju lizards, a group of reptiles which take the place occupied by the typical lizards of the Old World. Some of them attain dimensions rivalled only by the largest monitors; some approximate, in the gradual sacrifice of limbs, to the amphisbænas. These latter are amongst the strangest

THE SKINK

host, divided into five-and-twenty genera and over four hundred species. Singular forms are found in this family, many having squat, plump bodies supported upon tiny and widely separated limbs, while others, remarkable for vivid body-colours, have, for some unknown reason, the tongue brilliantly pigmented. It is believed that two interesting burrowing genera, the Anelytropidæ and the Dibamidæ, which pass a worm-like existence underground, are simply specialised or degenerate skinks.

PICTURES FROM WHICH WRITING GREW

AN EGYPTIAN FOWLING SCENE DEPICTED ON THE WALL OF AN EGYPTIAN TOMB

MURAL PAINTING OF THE INSPECTION AND COUNTING OF A FLOCK OF GEESE IN ANCIENT EGYPT

Pictures, or hieroglyphics, were first drawn to tell a story; then the figures were condensed into symbols, and the symbols shortened into letters that formed an alphabet; and so writing began.

INTELLIGENCE AND SPEECH

How Intelligence has Grown with the Growth of Speech, and Thought Forms Itself in Speech

THE SPEECH-CENTRE OF THE BRAIN

The study of the senses, of association, memory, and attention, leads us on to intelligence, which is ultimately associated with words and speech. The intelligent man does not necessarily write or speak at any given moment, but at least he thinks, and he cannot think above the lowest level without words. Thus the process of thinking, the intelligent process, is intimately bound up with speech.

Long ago we saw that the nervous system is a sensori-motor arrangement, which feels and replies. The brain itself is none other, fundamentally, than a sensori-motor mechanism; and if we study it as the organ of intelligence, we see its sensory side, above all, in terms of the hearing of speech or the seeing of written language; and its motor side in the act of speech, or in the act of writing. Nowadays, all of us who can read and write have this double mechanism, but in an earlier stage we simply have the original mechanism of hearing the sounds we call words, and reproducing them. The duplication of this primary process by means of writing and reading has had immeasurable consequences for mankind as a whole and for society. To us, here, it is simply a duplication, by eye and hand, of what we observe in the case of ear and speech organs. In any case, the whole thing is essentially one more illustration of sensori-motor action; but it utterly transcends all older forms of action, because of what the mind can do, in its deepest recesses, with those words which its senses receive and its will reproduces.

If the process were only sensori-motor, like being struck and striking, it would not detain us, but it incidentally gives the mind the incomparable instrument called language, the instrument of thought, by which it conceives, discovers, imagines, creates. We begin to see some significance in the Greek mystical use of Logos, or Word, as in the saying, "In the beginning was the Word." Words may often be feeble, foolish, empty, but they are the instrument, the indispensable instrument, and to some extent even the constructors, of thought, which is one of the supreme attributes, and is indeed the most nearly characteristic attribute, of man. As Bacon said: "Men imagine that their reason governs words, while, in fact, words react upon the understanding." We do well, therefore, to study closely the cerebral apparatus of *speech*, or *language*, words which both literally refer to what is spoken, but which may here be used as referring to words spoken and heard, written and read.

This study is as near as we shall come to intelligence, if we add it to what we have already learnt about memory and association. The brain does not provide us with any special structure or "centre" for thought or intelligence. We cannot point to any lobe or convolution and say "that is the thinking centre." The whole brain is involved in thinking; and when we come to examine the processes of thought or intelligence we see that they can be resolved into sensation, memory, association. That, so to say, is the dissection or anatomy of intelligence. We cannot come upon it as a whole, in some corner of the brain, and we cannot claim for it the distinction of being something new, unprecedented, unique, an extra, in the case of man. On the contrary, our analysis shows it to be a higher development of psychical facts, from sensation upwards, which are not peculiar to man. Any animal which can feel, remember, associate, is in some measure intelligent, which means that all animals, if not indeed all forms of life, including plants, are in

some measure intelligent. The human intelligence is only the highest development of powers which are older than man. On this all evolutionists, from the pioneers to Bergson, are agreed.

Further, before we study the particular kind of sensori-motor behaviour, feeling and response, which we call speech, and which is so characteristic of man, let us carefully observe that this, too, is only a higher development of ways in which intelligent behaviour is illustrated among the lower animals. It is, indeed, a fair question whether there is a greater gap between the powers of understanding and expression by speech seen in a highly educated dog and a yokel respectively than between the yokel and a man of genius or talent, in language written or spoken. We merely play with words if we say that a dog, for instance, cannot speak because it does not speak English. If an animal makes certain sounds to convey certain meanings, and if, further, it has learnt those sounds, and understands the sounds, such as words, made by human beings, in all essentials that animal has some measure of the mode of intelligent behaviour which we call speech when it is illustrated in man.

The Difference in Speech Between a Man and a Dog a Question of Degree

The differences between a dog or a parrot and a man are immense and potent, but they are differences in degree, not in kind. We have a larger vocabulary, a wider range in its use, a much more efficient mechanism of larynx, lower jaw, and tongue for purposes of mere articulation, and sensory organs which are capable of recognising and remembering far more and far more minute differences in sounds or in marks on paper, but all these assertions are comparative only. We therefore approach the exact physiology of human speech with due, but with no more than due, appreciation of its remarkable place in the wide scale of Nature.

Speech is essentially a sensori-motor act, as we have seen, and so we begin by reviewing the facts of its sensory aspect, which we may suppose ourselves to have studied. We have defined the visual centre in the occipital lobe of the brain, and the auditory centre in the temporal lobe. Presumably, then, words are seen or heard in those centres, and there is no more to learn about them. But the facts are much more complicated. It is true, and it is not true, to say that words are so seen or heard. They are there seen or heard, but they are not understood. They are seen as marks, which mean no more than, probably, Arabic writing to the reader; or heard as sounds which mean no more than Arabic words. The sheer seeing or hearing must be done in these centres or nowhere, but they do no more. If words are to be understood, if they are to mean anything, new centres must be educated. Words may be heard, remembered, repeated, as by a parrot, with a perfect sensori-motor mechanism, but that is only the imitation of intelligence, as much human speech may also be. If the process is to be true speech, truly intelligent, and capable of leading up to thought, the words seen or heard must be not only identified but understood.

The Word-Seeing Brain-Centre Developed by Education

We find, accordingly, that there is a "word-seeing" or "word-perception" centre in the brain, close to the visual centre, but distinct from it. The visual centre occupies the hindmost part of the cerebrum – the back of the occipital lobe. A little forward from it, only on the left side of the brain in right-handed persons, and *vice versa*, we find the "word-seeing" centre, which is only developed by education, though its capacity for such education is doubtless inborn. Here, and here alone, all words seen are understood. If it failed in your brain at this moment, on left or right side, according as you are right or left handed, and the left or right side of your brain is the "leading half," these words would still be seen as marks on paper, which you might even memorise and reproduce, but they would be just as if they were the characters of some language unknown to you. You would be what we call "word-blind." That is why we said that it is true, and not true, that words are seen in the visual centre; they are seen, but they are not seen as words. It need hardly be said that this applies to the reading of music or shorthand, as well as to ordinary language.

The Word-Seeing Brain-Centre Characteristic of Man

This fact of the existence of a separate word-seeing or symbol-understanding centre—for that is what it really is—could never be discovered except by the experiments of disease. It is a fact of man alone, though it may be that highly educated, highly educable animals may sometimes develop the beginnings of such a centre; and it is demonstrated in cases where a tumour

fracture, hæmorrhage, arterial blockage, or some other injury has chanced to throw out of action this centre alone. In such cases the patient sees but does not perceive the words in front of him. We may add that the recognition of familiar faces follows the same laws, though probably a separate part of the brain, near the " visual cortex," is educated for the purpose. If the " visual cortex " itself be alone thrown out of action, of course there is an end of all vision. The perceiving centre, though intact, has no material offered it for scrutiny and comprehension, for the patient is stone-blind. But if the perceiving centre alone be affected, he sees the print indeed, as most of us see Arabic or Hindustani, and that is all. A similar injury in the " led half " of the brain, such as the right half in right-handed people, would produce no symptoms at all, so far as the evidence goes. It has not been educated for this special function. It may be suggested, however, that the highest developments of language, in all its forms, may yet be proved to depend upon the education of the potential centres in both sides of the brain.

Forms of Disease that Affect the Use of Words

The technical name for any form of speech-failure, whether written or spoken speech, provided that it be due to the brain centres, and is not merely a defect of articulation, is *aphasia*. Mere defects of speech like stammering, or indistinct utterance due to defective action, and especially defective co-ordination, of the organs of articulation, do not here concern us, and should not be called aphasia, so different is their real nature. True aphasia is perhaps the highest and subtlest study in the whole range of neurology, because it brings the pure neurologist, the student of the brain and nervous action, closest to the psychologist, the student of the mind. Many large volumes have been written upon the subject; and its special significance for us here is that only the study of aphasia can reveal to us the normal physiology of speech. It is the experiments of accident and disease, some of them very rare, which have just chanced to define the respective details. They show that aphasia may take a host of different forms, and to each of these special technical names have been given. We need merely the English names; and we note, then, that what has just been described, regarding the presence of the word-understanding centre, is derived from observation of cases of " word-blindness." Pure word-blindness is the description of those rare cases where this centre has been thrown out of action, without any injury to the visual centre or to any of its connections. In such cases, the person who could read can no longer do so, but if the words be spoken to him he knows their meanings at once. So specialised, in " cortical representation " —*i.e.*, in allocation upon the *cortex cerebri*—are the individual portions of the universally distributed whole which we call intelligence.

The Curious Occurrence of Word-Deafness from Disease

Pass we now to the auditory centre, and precisely the same facts are found. The auditory or hearing centre alone hears. No hearing is possible without it, and all subsequent recognition or understanding of what is heard must first wait upon the sheer hearing. Sometimes injury or disease destroys this centre, and the result is partial deafness, or stone deafness if the centres on both sides of the brain were both destroyed. If, however, this pair of centres be intact, but damage be done to a small area of the cortex close above the auditory centre, on the left side only in right-handed, and on the right side only in left-handed, persons, then, though hearing will be perfect, understanding of language will be gone. If the person has learnt to read, he can still read. Anything scribbled " reaches his mind " at once, for the word-seeing centre is as intact as the visual centre itself. But the word-hearing centre is not as intact as the auditory centre, and the patient is, in short, a victim of " word-deafness." This name is not, perhaps, very accurate, but it conveys the required meaning. In this instance, also, the recorded cases are rare, for an injury or disease is not likely to destroy this tiny area without touching the auditory centre which lies just beneath it, but we have quite sufficient evidence to establish the facts.

Are Different Areas of the Brain Educated by Different Languages?

It is practically certain that distinct areas exist, or are educated, in the process of learning different languages. They are not all jumbled together; and the same is probably true of written languages and the *reading-centre*, for that is what the word-perception centre may be called. And now, of course, we can state, in terms of the brain, the nature of the process which we call learning to read, or learning to understand a language. The child which gradually associates meanings with sounds, so that it understands simple, often-repeated words,

is developing the potential powers of its word-perception centre. It does not require teaching to see. That is an elementary, native power of the visual centre, which was marvellously developed during months of utter darkness, and responds to the light when first the eyes open upon the world.

But the child requires teaching to read, because the association of certain sounds and certain meanings with certain designs, such as A or I, is not natural, but an artifice of man, and the child requires to form these artificial associations. Thus the central importance of association is again illustrated. We saw its importance for memory, and now we see its importance for intelligence. We have learnt to associate a certain idea with the symbol I, another with the symbol O, and so on. This association is the basis of all written language. A brain of humble type cannot learn to this extent, because it has not got the machinery of association. The vulture will see a letter O at a distance, where we see nothing, but the vulture's brain cannot understand the idea that O shall be pronounced as it is, and shall indicate what it does. That requires more than sheer vision, however acute, and depends upon the special development of a brain area which is capable of that development—the education of an educable area of the *cortex cerebri*.

Our Arbitrary Alphabet a Growth from Pictures Through Symbolism

No doubt there is a degree to which the association is simplified, because O suggests, perhaps, the rounded mouth which pronounces it, the widely opened eye of surprise; and just as the form of the letter is derived from the open eye, so the form of the letter I is derived from that of "man the erect." The hieroglyphics of ancient Egypt and the symbols of the modern Chinese show us the growth of a symbolic alphabet from pictures; but now, though the associations were originally natural, so that O and I suggested their meaning, perhaps, they are almost wholly arbitrary. There is no reason why B and P and R should not be pronounced R and B and P. A system of arbitrary associations, which we call the alphabet, has been invented, with invaluable results; and learning to read means, primarily, learning the associations between forms and sounds. The brain which cannot associate to this extent, like that of an imbecile, cannot learn to read, and the defect is rightly called a defect of intelligence. Thus the essential nature of intelligence becomes apparent.

Its psychological basis is quite simple; but if only it reaches the degree of complexity of association which it reaches in man, it becomes an instrument of unlimited powers. The invention of the alphabet was, from this point of view, probably the greatest in history. From it there followed not merely the possibility of writing things down and so retaining them indefinitely, but the much more important possibility of making ever more associations—the upshot of which is the boundless thought of man. But for this you must have a system of association-symbols which can themselves be associated, so as to form words, the number of which can be indefinitely added to, and to each of which special meanings may be attached.

The Greatest of All Inventions, that Opened the Road to the Infinite

Add a parallel arrangement of designs called numbers, and with the two we have the possibility of those products of intelligence which we call literature and mathematics. Their feature is that they are unlimited. Anyone may add to them. "No one can set bounds to thought," whether the thought of the poet or of the mathematician. Yet no Shakespeare nor Newton is possible unless he be born into a civilisation where this system of conventional associations has been elaborated, and unless he first masters them. They are simple and humble things, but they condition infinite things. We see now why even a Shakespeare or a Newton has to *learn*. Their native powers may be transcendent, their capacity of learning (which is making old associations) and of creating (which is making new associations) may be infinite, but no brain can be born with a knowledge of purely conventional associations like the meanings of words. Only the brain may be born with an area which can master these associations when they are presented to it.

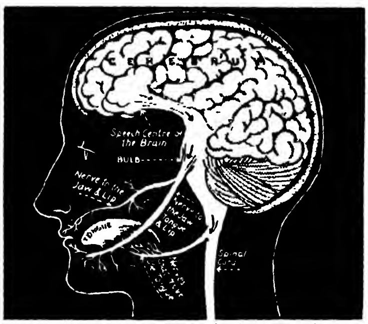
The Vital Importance of the Sensory Part of Education

Before we pass on to the motor aspect of speech, by voice or pen, we must observe that this sensory half of it, which we have discussed, is by far the more important. Everything depends upon it. Failing the sensory education, no motor reproduction of words is possible. In a word, the greater part of education is sensory. No doubt the child requires to learn to talk as well as to understand. No doubt articulation is a delicate art, and few of us ever speak a foreign language "like a native" of any

country but our own. But once one has learnt to pronounce any language, little further education is there required. You might go to an elocutionist, perhaps, for a study of voice effects, but no more.

On the other hand, sensory education is endless. There are all the words in the dictionary. You could pronounce any of them, perhaps half a million, but you have only learnt to know a few thousands. Your future learning of language, the instrument of thought, is thus essentially sensory; you can say the word all right, if you have learnt it, and if it "comes into your head" at the right moment, in thought or writing or speech, because it has formed the right associations with other words, and the ideas they stand for.

When we see how clearly the vital part of education is sensory, we realise how we judge the real education and intelligence of a man not by his pronounciation but by his vocabulary, by the number and fitness and variety of the words he uses. The motor details may interest us, showing whether English is his native tongue, and whether he learnt to speak it in Oxford or Edinburgh, or London or Cardiff, or New York or Adelaide, but in the long run what matters is the words themselves, and the learning of them was sensory, and the power to learn and use them is really sensory and associative and not motor.



The speech centre of the brain, known as Broca's area, is shown in this diagram. It controls the muscles of the lips, tongue, and jaws.

In learning words, whether novel scientific words, such as, perhaps, *aphasia* in this chapter, or in learning foreign words, or a line of poetry, we have all observed something which is of value besides the repetition which we have already referred to. We find that the process of learning words is much facilitated by speaking them. Many of us can remember the spoken far better than the written word; some of us—a minority—remember the written word better. This depends largely or wholly on the bias of the brain, already discussed, as to whether we are more "visuals" or "auditives." But it is quite certain that we shall remember best of all if the word be both spoken and written.

Psychologists used to assert that the auditory memory of words is far deeper than the vision-memory—that the word-hearing centre is much quicker and more easily educable than the "reading" centre, as we called it. Further inquiry shows that this is true of the majority, but not of all. In some, the reverse is the fact, and in some both centres seem equally educable. But for practical purposes everyone may confidently trust to the intentional employment of both centres for the best results. Lectures or remarks heard should be written and read. A play of Shakespeare's, carefully read, should be also heard, properly said at "the theatre" (which theatre? alas!), or should be recited aloud by oneself. Hence a musician, in learning a score, may merely read it, but he will usually play it or hum it, at least in parts, as well. Indeed, it is one of the arts of life, which all successful learners and creators know, to employ both of these "gateways of knowledge" in conjunction.

As regards words, certainly, the student in these modern days of books should not ignore the importance of the auditory avenue. It is *not* merely an avenue, but also a storehouse, having a definite brain area which holds associations between sounds and meanings.

Reading and writing are all very wonderful, but listening and talking come first. The visual memory for the forms of objects is deep, but the visual memory from words is relatively shallow, as it is recent in our history. The difficulty of spelling by sheer visual memory is familiar to many. But the auditory storehouse is of vast antiquity, vaster than the antiquity of man himself, for we cannot doubt that the apes, for instance, have a rude language, even though we do not necessarily accept the whole of Professor Garner's teaching on the subject. So old, so deep, so radical to the structure of the mind, is the auditory storehouse that, though we may not have realised it, *we think in unspoken words.*

Any reader who has hitherto inclined to question the importance we have attributed to speech as the basis, almost or wholly, of intelligence must duly weigh this simple and familiar fact—that when we, or the Spencers, Darwins, Shakespeares, think, they do so in unspoken words, the memory of the sound of which is faintly but

definitely aroused in the mind, doubtless through the help of the auditory word-centre. This centre, therefore (in the superior or uppermost of the three folds of the brain in the temporal lobe of the left side in a right-handed person), is the repository of those auditory word-images in terms of which we think.

How, in the Brain's Unspoken Sounds, We Hear to Ourselves what We are Thinking

Thus, the present writer is now thinking, and transcribing what he thinks. Except in moments of excitement, no word escapes his lips, but every word that is now flowing from his pen has just been faintly *heard*, has just been thought by means of unspoken sounds in his brain. The rest is mere mechanism; and he might just as well let the words he hears in the brain be uttered as sounds, and recorded by a gramophone or a secretary. The process of writing, therefore, is not only really speech, but it depends on hearing. It depends upon the action of the auditory word-centre; and every word which is written has been first heard, just as much as every note which the musician scribbles when he composes.

One does not *see* the sentence before it is written one hears it. The same is true of reading or thinking, as every child illustrates with its moving lips, or as old people who persist in reading letters aloud, or in thinking aloud, show. When we read silently, as when we write silently, we faintly hear, within ourselves, the sounds of the words which we read. Thus the auditory centre comes in where it is not really needed. One can read without it, as in the case of word-deaf persons, though the reading must be a strange process which does not go with a faint hearing of what we read; but when we who have normal brains read, the word-hearing centre always contributes.

The Pre-eminence of the Word-Hearing and Music-Comprehending Centres of the Brain

If any single centre of the brain is to be placed above the rest, no doubt the word-hearing centre, and its close neighbour, the music-comprehending centre--by means of which (though not by their means alone) all thought and literature and oratory and music are conceived, whether they ever be written or uttered or not—must doubtless have that pre-eminence. If you are right-handed, the portion of the skull a little above your left ear covers the area in question. These considerations provide the preliminary for a study of the deaf child and of deaf-mutism, the terrible association of dumbness or mutism with deafness, and the immense consequences of these defects for the whole mind—a study which might persuade some of us to do more for the prevention of deaf-mutism than public opinion in this country cares about. But we have no space here; and can only say that, compared with these people, and for reasons which the reader can now understand, happy and fortunate are the children who were born blind.

When we study the motor half of speech we learn that each centre requires a second centre, whether for talking or writing, as in the case of understanding words spoken or seen. The celebrated anthropologist Paul Broca, of Paris, discovered the "speech-centre" so called, or Broca's area. We have already seen various absolutely essential centres, however, without which there could be no speech. What Broca found—and it was the first case of cerebral localisation--was the centre for the motor part of spoken speech.

The Discovery of the Part of the Brain that Holds the Motor-Memory of Words

It lies in the lower part of the third left frontal convolution in right-handed persons, close to, but distinct from, the centre which controls mere articulation.

Broca's area holds the motor-memory of words. If it be damaged, the memory of words is lost, though speech is unaffected. The patient will clearly repeat words after they are heard, but he cannot produce them for himself. If no other part of the brain is affected, he can freely write his thoughts, but he cannot utter them. This, then, is the psychomotor centre of speech-perception, by means of which we say what we mean to say, and identify it as we say it.

Just similarly, the centre for memory of words to be written is not the mere centre for the movements of the hand, but lies close beside it. Damage of this centre, for "psychomotor graphic perception," causes loss of the power to write an answer, though it can be spoken. Thus, if the reader's auditory and visual word-centres will hold so much, as doubtless they will, we may distinguish between two forms of aphasia—***aphemia***, loss of power to speak; and ***agraphia***, loss of power to write. Either of these, of course, may be sensory or motor in origin, because speech and writing depend upon sensory as well as motor centres; and the sensory centres are involved in starting the motion, no less than in

mere reception of something seen or heard. The older and more natural centres, we have seen, are those used in hearing and replying, which every child learns first. Writing and reading duplicate the apparatus. Granted that we have all of these in good order, and well stored with sensory memories and associations, so that we, perhaps, know seven languages, are we then certainly intelligent ? Or is it possible to show oneself " a fool in seven languages "? Of course it is; and the fact indicates that these centres are not all.

The Many Centres of Brain Activity that Act in Concert

We have not yet called upon the resources of any but a little of the back part of the frontal lobes. What about the first and second convolutions (from the front) of those lobes? Doubtless there we should find, if we had as simple means of applying tests as in cases of mere aphasia, a number of centres, " ideational," "inhibitory," "associative"—we can at least name them!—by means of which, for instance, we hold our tongues when shouted at, or suppress the cruel or superfluous jest, or " change the subject." The brain is, indeed, as we began by saying, none other than a sensori-motor machine, but it is a machine with a master. Stimulus and response, insult and retort, sensation and motion, do not inevitably follow one another, notwithstanding the admirable machinery for the purpose which we have just studied. Volition and inhibition or control remain. Thus we can arrest or we can initiate.

By means of these highest centres, which nevertheless must use the lower ones, as they the lower still, we are capable of those internal processes—rarer in most of us than most of us suppose—which we call thinking, starting trains of reasoning or sequences of imagination.

The Fundamental Place of Words in the Anatomy of Intelligence

The formation of complex ideas, the power of steady attention or concentration upon certain subjects or chains of argument—all those higher powers by which alone memory and education and fluency and glibness can be made worth anything except to politicians—these are not explicable in terms of the centres we have discussed. They reside in the frontal and parietal lobes of the brain in especial; and from them there must proceed innumerable fibres which have the powers of arrest and of initiation, and which pass to all the lower, more " mechanical " centres which we have already studied.

Such, as nearly as we can arrive at it, is the structure or anatomy of the intelligence. Doubtless intelligence has more forms, more variations, than this account implies; and it is idle to deny that men " think " in musical sounds, in architectural lines, in colours, as they " think " in words. The processes involved are essentially the same. But words remain fundamental to all but these special and relatively rare forms of " intelligence." The total utility and value of the mind will depend upon the balance, no less than upon the individual development, of the various parts which we have described, and, above all, upon the highest centres, about which we had to be so vague. Failing these upper centres, which are always tending and threatening to fail in the wisest of us, the words which we have gathered in the lower ones are liable to become as bad masters as they would have been good servants.

The Dangerous Potency of Words in Obscuring Thoughts

This is the besetting danger of the intelligence, which Bacon, in his " Novum Organum," meant when he proceeded to discuss what he called " *The Idols of the Market-Place*," the most troublesome idols of all, which have entwined themselves round the Understanding from the association of words and names. . . . This has rendered philosophy and the sciences sophistical. Words define things by those broad lines which are most obvious to the vulgar mind; but when a more acute Understanding or more diligent observation is anxious to vary those lines, and to adapt them more accurately to nature, words oppose it. Hence the great and solemn disputes of learned men often end in controversies about words and names. . . . The Idols imposed upon the Understanding by words are of two kinds: they are either the names of things which have no existence . . . or they are the names of actual objects, but confused, badly defined, and hastily and irregularly abstracted from things."

The history of science and thought is full of illustrations of the dangerous potency of these indispensable creatures and creators of intelligence; and our analysis of the psychology of speech gives us some key to their power. But now we must proceed to something deeper, older, more powerful than intelligence—to those facts of instinct and emotion which largely use the intelligence as the mere instrument of their ends.

NATURE'S CHEMISTRY OF PURIFICATION

No one has yet been able to explain how the use of fruit wards off troublesome forms of disease, such as scurvy, but the fact is evident, though Nature's chemistry defies analysis.

SOME PROBLEMS OF DIET

What We Should Eat, and When and How We Should Eat It

THE VALUE OF APPETITE AS A GUIDE

BEFORE trying to tackle the difficult and disputed problems of dietetics, we dealt with a few common substances, which have been specially studied, and about which science may claim to have decided, at any rate in the main. Popular beverages, like tea and alcohol, have been considered, and also two great staples of diet, milk and bread. Our study of these will help us in dealing with diet in general; and even it we come to no definite conclusions on certain controverted points, it is something—much, indeed—to know what milk and bread are worth in building up the body.

We are all interested in diet, and have our views on the subject. Many unfortunate people are simply obsessed by it, to the exclusion of far more important matters. For them it should be said that diet is not at all as important as they think it to be. By this we mean that human adaptability is so high, the powers of the digestive canal are so various, and its faculty of choosing and refusing so great, that a very large number of people would probably be equally well, so far as we know at present, on any of several contrasted kinds of diet. From this point of view, many people study diet far too much. The psychical factor is also potent. A man really believes what some adviser suggests, and flourishes accordingly; the advice might be to take practically nothing but "raw meat and hot water"—the so-called Salisbury cure—or to take practically nothing but grapes and nuts. Many people, after a little internal training, could thrive for a long time on either. Here, therefore, we shall try to avoid extreme statements.

A very careful study of all the modern theories of diet has lately been made by a highly qualified physiologist and physician; and the conclusion of the whole matter, in his judgment, is that moderation is the all-important thing. Many opposed systems seem to obtain abundant success, and the common factor which serves them all is moderation. The mere restriction of the diet to one or two kinds of food—though in itself entirely irrational, and contradicted by the experience of those who abjure the foods in question, and are no less successful—usually means that the patient takes far less food than he did, his appetite being little tempted. If, as is very likely, he has hitherto been eating excessively, he now flourishes, but it is the reduction in quantity of his diet, not its quality, that "cures" him.

Let us, then, establish first principles, to which all forms of diet must conform. Our study of milk gave us the key to many of them. We saw that it contains two kinds ot proteins, and that indicates the first established fact of dietetics. There is no system of diet which consists of nothing but beef-tea or clear soup, because these are not foods, and the man will certainly die who attempts to live on them, however great his faith or his capacity for adaptation. Similarly, no amount of faith or dietetic education will enable one to live on sugar alone, or starch, or sugar and salts and water, or even sugars, starches, fats, salts, and water. Whatever the circumstances, we would shortly die, however carefully and generously supplied even with the last-named diet. Every animal organism, from the amœba up to man, must have proteins, or die. Perhaps the reader is more accustomed to hear of "proteids," and may be confused. The two names indicate the same class of compounds, but chemists have internationally agreed to use the form "proteins" henceforth.

That we must have proteins no one disputes. But one of the most obscure and disputed questions in dietetics is that of the

quantity of protein which is best for us. Here the differences of opinion are extreme. The old standards, introduced by the Viennese school of physiology in the middle of the nineteenth century, have been proclaimed as far too high by recent American students, especially by Professor Chittenden, the advocate of the "low protein" theory. Then come other students in this country, who say that the low protein theory is a mistake, and may lead to dangerous weakness, just as its advocates say that excess of protein leads to dangerous intoxication. On all this controversy we cannot presume to decide, but we have elsewhere hinted at what will probably turn out to be the solution of what, at present, is rather a mystery.

The Varying of the Value of Proteins by Their Quality

All proteins are not equal, because their internal constitution is different, so that a grain of one protein, say from milk, may be as useful to us as two grains of another, say from peas or lentils. But until this was discovered, students of diet made the serious mistake of supposing that one could measure the nutritiousness of any article of diet, so far as its protein was concerned, by ascertaining how much protein it contained. Thus it can easily be shown that peas and beans, for instance, are very rich in protein, and much vegetarian argument has been based accordingly. The case must be called not proven until we know a great deal more; but the chances are that we shall discover the animal proteins, as a whole, to be far more like our own proteins in constitution than those of vegetable origin, so that much of the apparently high nutritive value of some vegetable foods may prove to be rather delusive.

Digestion and Absorption as Tests of Food Values

All the old chemical tests on which we relied as final must be in future looked upon as merely preliminary. We *do* want to know whether or not a food contains protein, or is "nitrogenous," as we often say, and, if so, how much protein it contains; but when our predecessors estimated the nourishing value of all foods by such tests we know that they were deluded. We live not by what we swallow, nor yet even by what we digest, but by what we swallow, digest, and absorb.

Much food material which other creatures could live by is useless or almost useless to us, because we do not even digest it; and our digestive fluids may suitably prepare various substances which the cells that line the alimentary canal decline to take up into the blood. Plainly, no estimations in test-tubes outside the body can be adequate, and the knowledge which would really be adequate, because practical and human, does not yet exist.

Again, within the last few years the physiology of diet has made the quite novel discovery that there must be an unknown number of substances in our diet—present in very small quantity, and unidentified by chemistry hitherto—which make all the difference to our lives and health. Facts telling in this direction have, of course, been noticed for a long time. Seamen fed exclusively on certain kinds of diet, without fresh fruit or vegetables, develop a disease of nutrition which is called scurvy. In terms of orthodox dietetics, nothing was amiss with their diet; they had plenty of each of the various things—proteins, carbohydrates, fats, salts, and water—which we are understood to need, but they sickened and died nevertheless. An unknown but vital something was missing.

Nutrition Dependent, to Some Extent, on Unidentified Compounds

Then again, infants fed exclusively on sterilised milk may develop what is often called "infantile scurvy," another disease of malnutrition, which disappears when fresh orange or lemon juice is added to the baby's diet. But we cannot state the difference between sterilised and unsterilised milk in terms of orange-juice, as if the sterilisation had destroyed orange-juice which was present in the untreated milk. No such thing is present, of course, but something is, which we cannot identify, but which is necessary for health.

Further, there is the long mysterious disease called beri-beri. In India and Ceylon and other parts of the world certain people are almost suddenly taken with an illness which involves inflammation of the nerves, great weakness of the muscles, painful rigidity of the limbs, and general symptoms of poisoning. It looks as if they had been attacked by something comparable to the arsenic, lead, alcohol, etc., which are known to produce similar symptoms. No such cause could be found. A microbe or other parasite was long hunted for, without success. But now it has been proved convincingly that the symptoms are all due to the lack of something from the diet of the patient. He has been living almost exclusively on rice which has been "polished," the outer skin of the grain having been

removed. But that outer skin contains minute traces of a chemical compound without which the disease called beri-beri will appear.

Discoveries of this kind complicate our science of dietetics beyond reckoning. We evidently have to deal with the action of a whole host of substances of which we know nothing, but any one of which may be essential for health. It was bad enough when physiological chemistry showed that we must no longer speak of "the proteins" as if they were practically similar for dietetic purposes; and now we see that our nutrition largely depends upon a number of compounds which have not yet been even identified or named.

A Varied Diet the Most Likely to be Suitable

Such being the state of things, there is at least one simple prescription, quite welcome to all ordinarily constituted people, which we must proclaim—and that is *variety*. In each of the three cases which we have quoted, there is an essential factor at work which we cannot name, but we can readily control all three of these diseases by making the diet more varied. In each case the patient became a patient because his diet was restricted in kind, and thus came to omit an unknown something which indulgence in a more varied diet would surely have supplied.

Moderation, then, about which we shall have to say more later, was the first keynote of a soundly contrived diet, and variety is the second. This last is a necessity imposed upon us by our ignorance. The doctor prescribes opium, which contains some twenty alkaloids and hosts of other substances, until he learns that there is just one, called morphine, which he really wants. When we know a hundred or a thousand times as much about dietetics as we do today, we shall no doubt be able to prescribe an extremely restricted diet, if necessary, without risk. But at present we run the risk of excluding something which is necessary, and about which we know nothing.

The Mistake of a Varied Diet in the Case of Infants

We have what might almost be called an instinct in favour of a varied diet, an instinct which is the undoing of many an infant. The infant is the sole and absolute exception to our rule of variety, just exactly because the infant's diet has been specially composed and prescribed for it by Nature, who knows what she is about. She gives it what seems to us to be a most restricted and unvaried diet, and we feel that this is too bad, and begin to add all manner of things to supplement its monotony. Many mothers still exist in this country who destroy their infants, with the best of intentions, by giving them "what we have ourselves." But, in fact, even milk is a highly complicated diet, with a host of constituents which we can isolate, and others of which we as yet know nothing except that they are there.

For the adult man or woman variety in diet is most desirable, and it is no less so for the developing child, the schoolboy and schoolgirl. No doubt serious injury must have been done to hosts of children in the past by the restricted diet which was thought good for them—restricted not in quantity but in quality. "Abundance of good, wholesome food" may be inadequate if it be not so varied as to give the body the chance of picking out enough of all the many things—far more than we used to think—which it requires. There are careful and scientific students of consumption who consider that one of the chief reasons which account for the great decline in the incidence of that disease is the vast improvement in the feeding of the people which modern commerce has made possible; and that improvement may just as much consist in a greater variety of diet as in any increase in its mere bulk.

A Healthy Appetite the Best Guide to Sound Habits of Feeding

The teeth of man are quite well suited for many kinds of food. His digestive canal produces a large number of ferments of different kinds. His appetite naturally inclines towards variety. Each of these is surely a significant natural indication. The revolt of the schoolboy or the convict, when the same diet is placed before him, yet again, "good and wholesome" though it may be, and abundant too, probably has a sound physiological basis. The appetite which asks for at least a reasonable variety in diet is probably the healthy and the safe appetite. Indeed, so ignorant of many essentials of dietetics have we lately found ourselves, with advancing knowledge, to be that it looks as if the healthy appetite were perhaps the best of all guides to sound dietetic habits.

What we have called the new asceticism will not be so foolish as to deny that appetites of all kinds are capable of being indulged to excess. Much less will it question that appetites of all kinds are capable of perversion and vitiation. But it

will avow that the perfectly healthy body, and often the body in disease, is equipped with appetite as a guide and counsellor and friend; and even that *that body cannot be regarded as ideally healthy the appetites of which are not trustworthy and beneficent.* The old asceticism said, "Stifle and deny your appetites;" the new asceticism says, "Train and rehabilitate your appetites;" and that is the difference between them.

Now, if the body displays any appetite that is liable to undergo perversion, it is the appetite for food, the existence of which is the simple answer to the question how in the world a tiger or a tapeworm manages to feed so well and efficiently, though it has never heard of calories, or Prof. Chittenden, or "nitrogen equilibrium." If we did not make it part of our system with ourselves, and with our children from their earliest years, to deny, outrage, cheat, magnify, and vitiate the appetite for food by every means which silly ideas of morality, the artifices of cookery, and so forth can suggest, we should find in our appetites something to make the whole science of dietetics almost superfluous, and should rival the admirable and enviable state of such of the lower animals as have not been domesticated and corrupted by man, wherein the eater eats what he needs, when, and as he needs it.

Man's Departure from the Universal Habit of Taking Simple Food

What an ideal, and how incredibly remote from human practice and the hopes of the most optimistic hygienist! And yet it is the common daily state of every vegetable organism on the earth, and every animal except man, the paragon of animals, and those domesticated animals on whom he has practised his wiles.

Very likely the reader's appetite at the present moment is not to be trusted. Most of us have *acquired* a host of tastes, for instance. Probably, if we remember the theory of evolution, and look at the kinds of things for which we acquire tastes—alcohol, tobacco, high game, condiments, and so on—we may agree that all acquired tastes in physical matters are bad, or, at any rate, not worth acquiring. If every normal human organism evinces at first a repugnance to tobacco or whisky or mustard, we may have sufficient faith in the forces that framed us to believe that their verdict is probably correct. No doubt, the young organism has needs which are to some extent peculiar to itself; but even here we may note that the dislike of sweet things shown by many adults (who loved sweets when they were little) is certainly not a sign that the organism no longer needs sugar, that irreplaceable fuel, but is very often the consequence of vicious changes in the appetite produced by alcohol and tobacco. The father who accuses his child of greed or vicious appetite when it wants another sweet (for which he has no desire himself) requires to be told that the child's desire is an organic virtue, and his lack of desire an organic vice. He is the sinner rebuking innocence.

This doctrine that appetite was given us as a guide to be followed, not as a tempter to be spurned, is very rarely practised, even by those who may incline to look upon this assertion of it as superfluous.

The Failure to Follow the Lead of Appetite in Hot Weather

For instance, what does the reader do in hot weather, or when he has a feverish attack, or a cold in the head, and his appetite fails? If he believes himself to be reasonably made, and follows the natural indication in these cases, he has nothing to learn from these pages. But, in point of fact, when the warm weather comes, the reader probably throws overboard all his principles about the rational structure and functioning of the body. He finds his appetite, usually so vigorous, failing. Something must be done. Perhaps, therefore, the reader abuses his cook, is rude to his wife, snubs his children, and even goes out to "get a decent dinner." Doubtless he can cheat his appetite somehow. But in warm weather we naturally need less food or fuel; and the man who will not follow the indications of his appetite is well on the way to over-eating, degeneration of heart and arteries, and premature senility, so-called signs of which may be found in at least half the prosperous men of forty today.

The Failure to Understand the Wisdom of Appetite in Feverish Cases

Or take the case of the feverish attack. Here the failure of appetite is not the disease, nor is it one of the injurious consequences which make the disease a disease; it is a method adopted by the body in its fight with the cause of the fever. Yet you will endeavour to "force down" something, unaware that, in fever, the blood is so busy with more urgent matters that it cannot properly supply the special needs of the digestive organs, and therefore the stomach secretes no hydrochloric acid—and indigestion is the result.

Fairly treated, appetite is not a will-o'-

the-wisp, but a true guide. There are two definite states of the mind or body, or both, in which the failure of appetite normally endeavours to warn us against the danger of eating. A man should not eat any but the lightest meal when he is fatigued. There is, of course, such a thing as normal fatigue, which is rapidly recovered from under the influence of rest; there is also the abnormal or noxious fatigue which too many of us know. But there does not exist, in ordinary life, fatigue due to the using up of the available food supply of the body.

The Uselessness of Food when One is Poisoned by Fatigue

We might become exhausted from sheer lack of nourishment, but actually we become exhausted by self-poisoning, long before our available stores have run out. A characteristic symptom of undue fatigue is lack of appetite. If such fatigue were due to need of food, we should expect an increase of appetite to be a symptom of it, but we find the opposite.

The truth is that the over-fatigued body, poisoned as it is by the by-products of work which have not yet been got rid of, is incapable of doing the further work, nervous and chemical, which we call digestion, and endeavours to protect itself against this further burden by a failure of appetite. A full meal taken in a state of marked fatigue is certain not to be utilised. It can be swallowed, but it cannot be digested. It is quite likely to cause acute indigestion. Your business in such a state is to rest. When you have rested adequately, your power of digestion will return, and your appetite with it.

Again, a man should eat only the very lightest of meals when he is in a state of acute vexation or worry—if not, indeed, any acute emotional disturbance whatever. One of the results of marked emotion—it may be extreme fear or extreme joy—is to arrest the secretion of the digestion juices.

The Protective Effects of a Want of Appetite in Extreme Emotion

We should learn from the hint afforded us by the fact that the mouth becomes dry as a symptom of fear. Along with extreme states of emotion there is therefore a protective failure of appetite, which we ought to recognise. If appetite fails, is lack of food the likely cause? Plainly not; the normal consequence of lack of food would be increased appetite. If lack of food, then, is not the cause of lack of appetite, the supply of food is not its remedy. If, in defiance of the natural indication, we force ourselves to eat during such states of emotion, we shall suffer just the same consequences as when we force ourselves to eat during fever or during extreme fatigue.

If one is to have the kind of appetite which can be safely trusted at all times, as regards both quantity and quality of food, it is never too soon to begin. It was left to Herbert Spencer, in his famous chapters on "Education," published more than half a century ago, to discuss this subject in its relation to childhood. Some modern parents practise what Spencer preached. A distinguished medical man lately told the writer of his own boy, then eight years old, who had had what he pleased, as and when he pleased, all his life, nothing he desired having ever been refused him, except on one occasion when he wanted vinegar; and the result was as good as could be. The diet of this fortunate boy was thus actually as perfect in its adaptation as that of any animal. But it will be evident that, if you habitually deny your child or yourself what Nature demands, you cannot reform your practice in an instant, else you will pay for the inevitable reaction. You have vitiated the appetite, and cannot trust it until its right action has been restored.

The Individuality of Appetite a Reason for Avoiding General Rules

The appetite varies in different people, and under different conditions. If it be a sound and properly nurtured appetite, it varies in accordance with the special needs of the individual, knowing that "one man's meat is another man's poison." There are real, inherent variations in the bodily constitution and chemistry of different individuals which that proverb expresses; and they render impossible the application to any individual of any but the most elementary- not superficial—dogmas regarding either quantity or quality of diet. The reader who remembers a very early chapter in this section will understand how "the candidates for health" vary in their needs. It is just our recognition of this that leads us to abandon the idea of prescribing diets for all readers, and incites us to request the reader to develop and to trust his own personal, individual guide, which is his appetite. If it be a healthy, well-treated, and respected appetite, it knows more about what is good for its owner than all the physiologists and prescribing doctors in the world.

Besides the inherent differences between people, there are many acquired differences, which we need to understand. These may be due to habit merely. Feed a pig on proteins, and its pancreatic juice is found to contain mainly the protein ferment; feed it largely on starches, and the juice contains mainly the starch ferment. Make a sudden change in either direction, and the result must be disastrous. Besides habit, there is what we nowadays call suggestion. You taste a bad egg, and cannot eat the freshest of eggs for months afterwards. You have raw eggs during illness, with the same result. You are given endless blancmange or golden syrup in your childhood, and can never touch them in after years. "Children should learn to take what is set before them," we say. It is not our rule with ourselves. You do not even allow for a miscalculation. Your child asks for a second helping, and stops after the first mouthful. You compel the unfortunate to finish what it asked for. So much the worse for its appreciation of that dish when you are gone. How would you like to have some blundering, tyrannous giant, eighteen feet high, treat you so? What a rare and astonishing insight into the needs and misfortunes of childhood half a day of such a giant would afford you!

Herbert Spencer's Plea for Allowing Children to Eat What They Like

Herbert Spencer showed how much better it is to respect a child's appetite and allow it to develop naturally in the way it should go. He says: "There is an over-legislation in the nursery, as well as an over-legislation in the State, and one of the most injurious forms of it is this limitation in the quantity of food. 'But are children to be allowed to surfeit themselves? Shall they be suffered to take their fill of dainties and make themselves ill, as they certainly will do?' As thus put, the question admits of but one reply. But, as thus put, it assumes the point at issue. We contend that, as appetite is a good guide to all the lower creation—as it is a good guide to the infant—as it is a good guide to the invalid—as it is a good guide to the differently placed races of men—and as it is a good guide for every adult who leads a healthful life—it may safely be inferred that it is a good guide for childhood. It would be strange indeed were it here alone untrustworthy."

Then Spencer goes on to show that the instances of excess, quoted by his opponents, "are usually the consequences of the restrictive system they seem to justify. They are the sensual reactions caused by an ascetic regimen. . . . Consider the ordinary tastes and the ordinary treatment of children. The love of sweets is conspicuous and almost universal among them. Probably ninety-nine people in a hundred presume that there is nothing more in this than gratification of the palate; and that, in common with other sensual desires, it should be discouraged. The physiologist, however, whose discoveries lead him to an ever-increasing reverence for the arrangements of things, suspects something more in this love of sweets than is currently supposed; and inquiry confirms the suspicion." The case is similar with fruit; then, when the child has the chance, it makes itself ill with sweets or fruit, and "it is argued that children must not be left to the guidance of their appetites."

How Confidence in the Laws of Nature Grows with Knowledge

The pages from which we quote, occurring in the chapter on "Physical Education," are the purest wisdom, and have played their part in history, for they greatly helped to reduce the false notions against which the author inveighed. The reader will do well to consult them in full. Then Spencer proceeds to make, as regards children, the point upon which we insist here—that no other guidance than healthy appetite is worthy of confidence. He names a few of the factors that decide how much food we need at any given time, and says: "In truth, this confidence, with which most persons legislate for the stomachs of their children, proves their unacquaintance with physiology; if they knew more they would be more modest. . . . In proportion as men gain knowledge of the laws of life, they come to have less confidence in themselves, and more in Nature."

The Question of How to Eat More Important than What to Eat

It is probable that, for most people, the question how to eat is more important than the question what to eat. At any rate, it is so important that it should here be ranked beside our initial study of the appetite.

We should not eat when we are fatigued or worried, or when we are not hungry. But, more than that, we should eat with positive zest and pleasure. Hunger and appetite and pleasure are the best sauce, because they do supremely well what sauces try to do—stimulate the action of the digestive glands. Company—which

literally means bread-together—is therefore normal and desirable, because of its psychical action on the physical processes of nutrition. Solitary meals usually tend to become unhygienic. They are hurried or over-elaborated, and lack pleasure. If one must eat alone, much is to be said for the book or paper which some strict sects of hygiene condemn.

The book gives you the company you require, allays annoyance between courses, and slows the speed of eating, which is apt to be extreme when one is solitary. The book thus serves the same purpose as the fashionable dinner—with certain advantages of its own; for in sooth the well-chosen dead are often better company than the living—they are so much more alive.

The Great Need for Slowness in Taking Meals

The mere mechanical speed of a meal is an important matter. There can be no question that it is well to eat slowly, and this is one of the chief objections to the solitary meal. Except for the gourmet, the thing itself is not sufficiently interesting, and so we bolt our food. The "quick lunch," which we eat perched on a stool, in an atrocious atmosphere, glare, and noise, is quite indefensible.

Mr. Horace Fletcher, an American gentleman who lives in Venice, has persuaded many people that mastication is the real secret of success in eating. He has doubtless exaggerated a certain truth. It is not necessary to turn over every morsel in our mouths, or even to be more than intermittently conscious in a secondary way that we are eating at all. One can eat and write simultaneously, and enjoy both; and there is something pitiable about the man who will not jump from his chair during a meal in order to settle a point. But one must masticate. This may be done of set purpose, and on a plan—say, thirty-two bites per dose, giving each tooth a chance. Starvation sounds a welcome alternative to this.

The Important Part Played by Mastication in Securing Health

The right method is to acquire the habit of proper chewing in youth, and to maintain it, with the aid of properly cared for teeth.

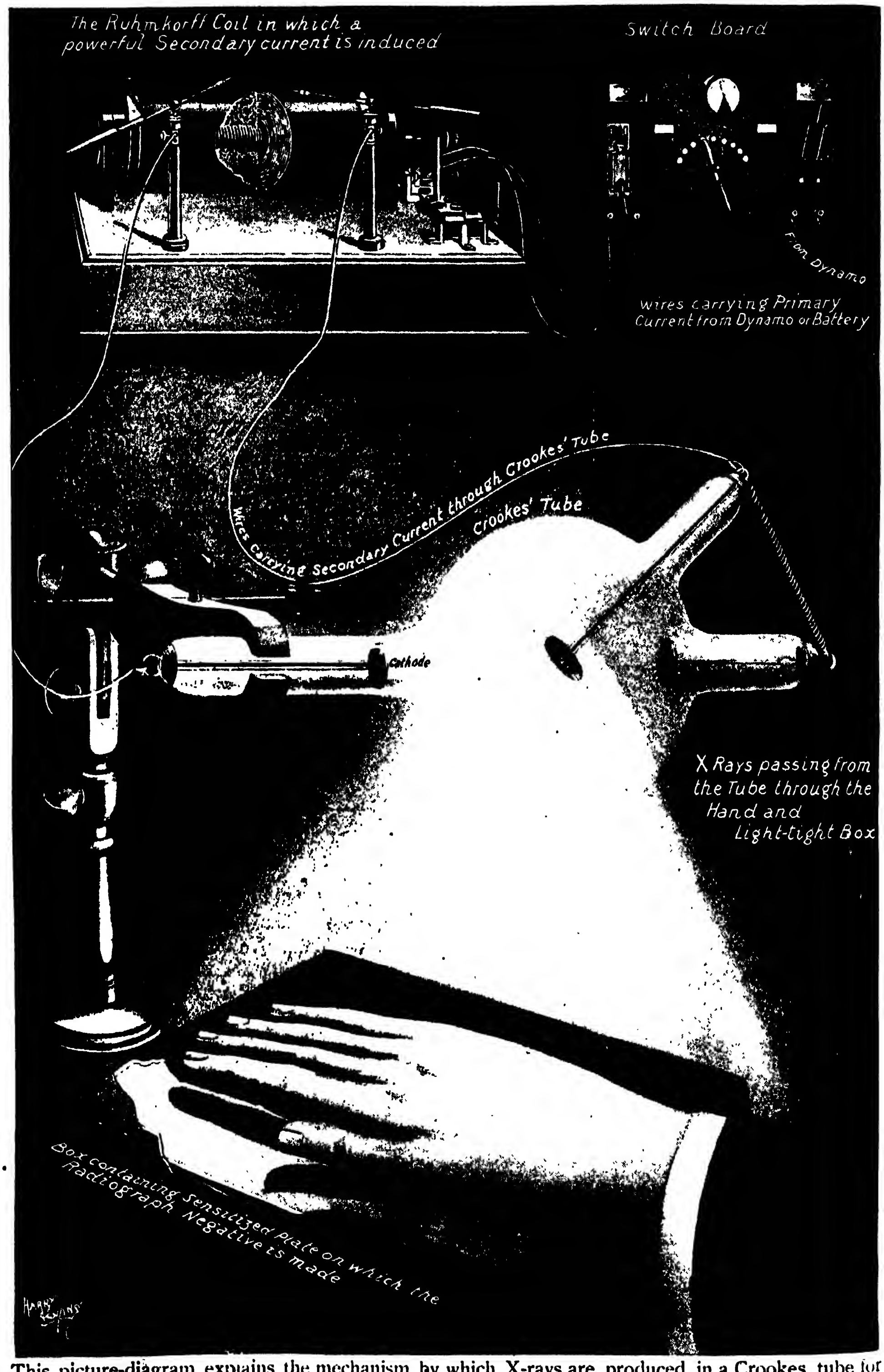
The stomach has no teeth; and though its walls are muscular and active, they are thin and quite incapable of crushing anything. If the teeth do not do their duty, nothing further on can replace them. On the other hand, many a man digs his grave with his teeth; and many an elderly person would live longer if he were deprived of his artificial teeth and fed accordingly. Thus, while we insist upon the importance of mastication, we must add that his artificial teeth may do the elderly man injury, by permitting him to abuse his appetite, which is artificially stimulated by the modern resources of food supply and cooking. This, however, is not really the fault of the teeth; and it is impossible to agree with those extremists who condemn artificial teeth, which are an incalculable blessing to those who use them properly.

The mouth does more than carry the teeth—it provides a digestive fluid with which all food that contains any form of starch, such as bread, should be soaked before it is swallowed. Food like new bread can scarcely absorb the saliva, and food which is bolted suffers similarly. The argument, then, is in favour of a somewhat dry food and the use of *little* fluid, at any rate at the beginning of a meal, for the mouth should be left to supply its own fluids, which have their special action. Besides the obvious uses of mastication, we have to remember that the stimulation of the mouth starts reflex processes going in the stomach, and that the stomach secretes its acid fluid all the better if it receives a good supply of alkaline saliva in the food from the mouth.

The Wisdom of Ceasing to Think About Food when It Has Been Eaten

Once the food is swallowed, it should be utterly and finally forgotten. If it has been reasonably chosen and chewed, we as conscious individuals have done our whole duty to it; the rest should be left to the body, and should not be imperilled by a single thought. Immediately after a meal, sit in a chair and deliberately picture to yourself the movements which are going on in your stomach, and speculate as to whether the chemical changes are going on rightly. At once you will feel definitely uneasy. This experiment should suffice for a warning. Your true food-faddist may sometimes place himself in this plight, as too often does the dyspeptic. As the writer has argued elsewhere: "No measure of conscious attention to digestion can be anything but injurious. From the completion of the act of swallowing, or before it, we should think no more about the subject; we can effect nothing but harm in doing so. The latest, highest, and most characteristic part of man (which resides somewhere in the higher areas of his brain) was not evolved for purposes of introspection of any kind, but for looking outwards, if not upwards."

SHADOWGRAPH OF THE HAND'S INTERIOR



This picture-diagram explains the mechanism by which X-rays are produced in a Crookes tube for the purpose of radiographing a hand placed on a box containing a sensitised plate.

The photographs on these pages are by courtesy of Messrs. Watson & Sons, Mr. F. H. Glew, Messrs. J. Leadbeater & Sons, The Sanitas Electrical Co., and others.

THE MARVELLOUS X-RAY

How Man Broke Up the Atom and Discovered a Strange, New, Radiant Power

THE MAGIC TUBE OF MODERN SCIENCE

No achievement in science ever created so sudden, keen, and large an interest as the discovery of the X-ray by Röntgen in 1895. Mankind suddenly found itself endowed with a strange and wonderful power of vision through flesh and wood, and even steel. The science of medicine was revolutionised, some of the most difficult feats in surgery became easy tasks, and the nature of many obscure diseases was clearly and quickly revealed. Among men of science the wonder was greater than among the general public.

For the almost accidental and altogether unexpected detection of the new ray opened up fresh and far-reaching vistas of knowledge and power, that made everything hitherto known about the material structure of the universe seem of secondary importance. And, throwing themselves with renewed energy into the paths opening out before them, some men and women of science in England and France quickly made a new series of marvellous discoveries in regard to radiant matter. So the nineteenth century closed in a blaze of new experiments and researches of tremendous moment. The structure of the universe was broken up, and the primordial energy that builds up every variety of matter was abruptly revealed. Every man who had eyes to see it could say:

> "It seemed
> A void was made in Nature; all her bonds
> Crack'd; and I saw the flaring atom-streams
> And torrents of her myriad universe,
> Running along the illimitable inane,
> Fly on to clash together again, and make
> Another and another frame of things
> For ever."

All this was the result of some seemingly useless experiments with a little tube of glass, emptied of air, and made to glow inwardly with an electric current! For many years these experiments had appeared to be the unprofitable amusement of a few learned men, who might have been doing more useful work. But, as the sequel proved, great events in science often have small and obscure beginnings. In the general search for scientific truths of vast scope, it is not always the immediately utilitarian scheme of research that proves in the end to be of high value.

The disinterested feeling of curiosity which is the master passion of the modern man of science often leads him to devote his whole life to some apparently trifling matter that seems utterly without practical importance. For something more than half a century a small band of men passed some of the best part of their lives in playing with a little glass tube through which they sent currents of electricity. The glass tube was a modification of the ordinary closed arc lamp. It was emptied as far as possible of air, and two carbon or metal points were fixed inside it, and connected with the wires of an electric battery. In the ordinary way, a spark was created by the electric discharge across the air-space between the two points. When, however, most of the air was pumped out of the glass, the electricity passed more easily from the point at one end of the tube to the point at the further end, and a luminous glow was created. Sometimes, when the glass tube had been fairly well exhausted of the natural gases of the atmosphere, a slight amount of some other kind of gas was introduced, and an electric current was passed through it.

It was very troublesome to pump the air out of the glass so as to get a high vacuum, but the men of science went on with their difficult work, never dreaming of the wonderful results that they were slowly elaborating. For many years their little byway

of science, which is technically called the conduction of electricity through gases, was hardly worthy of notice in a text-book. For nothing seemed to happen when the electric current was sent through a gas, except that less electric power was needed to send a current through a partial vacuum than through ordinary air. But this had been known for a long time.

The Scientific Search for Facts, not for Sensational Discoveries

It is, however, a characteristic of the true man of science that he works very often with no hope of making any startling discovery. All he wants to do is to discover a little scrap of fact. He is a brickmaker in the temple of science, and he is not greatly concerned whether his brick goes into the hidden foundation or shines in the sunlight from the topmost tower. Enough for him that he has discovered a bit of truth. Hence, as some entomologists give all their lives to the apparently dull and routine study of some single insignificant form of life, and die and leave their work to be extended by generations of other students, so the physicists who took up the very unexciting problems of the conduction of electricity through rarefied gases went on with their labours, and passed away without adding apparently anything of importance to the sum of human knowledge. Yet some men who took up the microscopic examination of certain insignificant insects are now famous as the underbuilders of the great, vital science of the prevention of the spread of the germs of various deadly diseases; and the small band of scientists who devoted themselves to the study of the conduction of electricity through gases have won posthumous renown by reason of the almost chance and yet crowning discovery of the X-ray, that revealed to all the world the magnificent importance of their obscure labours.

The Often Unrealised Value of Facts Reached by the Passion for Research

This is why the disinterested passion of research of the man of science is exceedingly valuable. So strange, complicated, and mysterious are the processes of Nature that it is impossible to foretell the outcome of any special line of research. Science cannot be directly useful in its particular aim, because this aim cannot often be perceived. When in 1859 Plucker managed to produce in a glass tube a higher vacuum than had before been achieved, the electric current sent through the tube created a pretty effect. On the walls of the glass tube appeared a greenish phosphorescence, that Plucker traced to the action of rays sent out by the cathode. We must explain that the metal point by which the electric current enters the tube is called the anode, or upward path; while the point from which the current leaves the tube is called the cathode, or downward path.

It is sufficient to remember that the cathode ray is created by the electrical current at the cathode. It then shoots from the cathode to the side of the vacuum tube, and there produces a beautiful coloured glow. This Plucker discovered in 1859. And he found that he could alter the course of the cathode rays by means of a magnet placed outside the glass tube. Plucker himself did not suspect the extraordinary importance of these discoveries; neither did anybody else. Indeed, it was thirty-six years before the marvellous properties of the new ray were made use of. In the meantime, Hittorf, another German man of science, took up the matter, and found in 1869 that the cathode ray could be stopped by placing inside the tube a solid screen fixed between the cathode terminal and the sides of the tube.

A Battle of Inquiry Between English and German Men of Science

It was then thought that the cathode ray consisted of waves of ether akin to the electro-magnetic waves of light; and everybody was astounded when Sir William Crookes in 1879 based on some new experiments with the cathode rays the theory that they were streams of exceedingly small particles of matter, negatively electrified and projected with great speed.

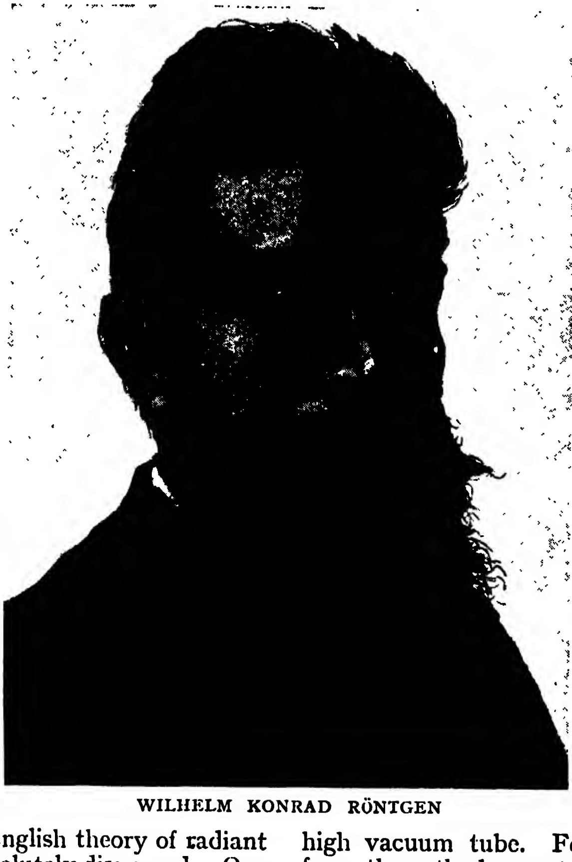
Sir William Crookes's experiments may fairly be said to have opened up all the new sciences that have come out of the little tube of glass. Using a higher vacuum than other men of science had then been able to obtain, Crookes produced a more powerful cathode ray; and this enabled him to study the properties of the strange new force with more clearness and more minuteness than any other observer had done. He found, for example, that when the cathode ray struck against a little vane placed inside the tube in the path of the ray, the vane rotated in the same direction as it would take if it were being bombarded by a stream of exceedingly small shining bullets. And on this and other deeper grounds the now famous English man of science founded his theory of the existence of radiant matter.

In Germany the theory was received

THE RADIOGRAPH OF A FROG

THE BONY SKELETON OF A YOUNG SQUIRREL AS REVEALED BY A RADIOGRAPH

with derision. And it remained for many years the chief battlefield between the British school of physical science and the German school. And perhaps it was partly in order to prove that the English view was entirely wrong that three German men of science resumed the study of the strange ray. Chief among them was Heinrich Hertz, the famous discoverer of the electric waves and the father of wireless telegraphy. Hertz was, of course, a disbeliever in Crookes's idea, but he was also an experimenter of high genius. And he at last found a way, to all seeming, of proving in a conclusive manner that the new ray was not formed of material particles, but of waves of electricity. For he fitted a very thin window of aluminium in the part of the vacuum tube against which the cathode ray shot from the cathode. And, strange to say, the marvellous ray passed through the sheet of aluminium, and lighted up the air for a little distance outside the tube.

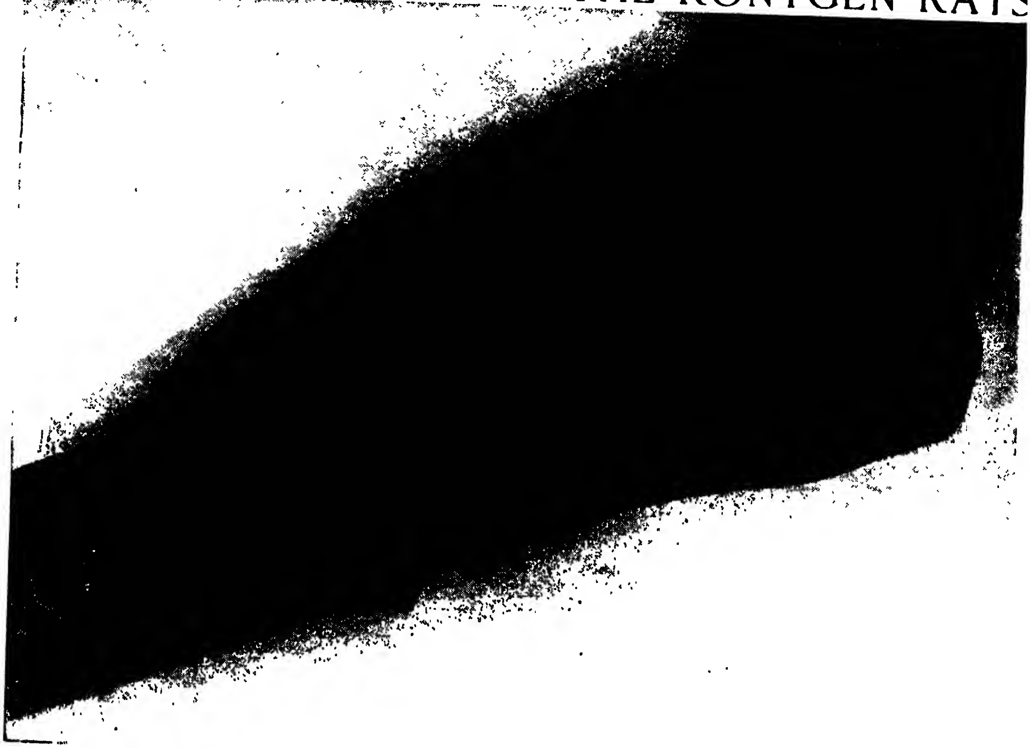


WILHELM KONRAD RÖNTGEN

As it was then impossible to conceive that a radiant form of matter could pass through a sheet of gold or aluminium, the German school of physical science reckoned that the English theory of radiant matter had been absolutely disproved. One of Hertz's pupils, Philip Lenard, continued his experiments; and in 1894 he produced so powerful a cathode ray that it could penetrate certain metals in much the same way as a ray of daylight penetrates a film of translucent marble. The next year Wilhelm Konrad Röntgen, the Professor of Physics at Würzburg, took up the matter at the point at which Lenard had developed it, and discovered the marvellous X-rays. As is well known, "X" is used in scientific calculation to denote an unknown quantity; and it was because he could find out little or nothing concerning the nature of the second new ray that Röntgen called it the X-ray. It is still the unknown quantity in modern science.

It is produced by the cathode ray. When a cathode ray strikes against anything, it creates an X-ray. When the sides of a glass tube, from which nearly all the air has been pumped out, are lighted by the cathode ray, the X-ray is also present; it is streaming through the glass into the room. But the trouble is that the glowing tints of the cathode ray are easily discernible by the unaided eye, while the X-ray is unseen. Whenever there is a high vacuum in the glass tube through which the electric current is passing, the cathode ray is perceived. It begins with a green phosphorescence that changes, as the air is more and more exhausted from the tube, into a yellow glow. And by means of a gold or aluminium window this glow can be produced in the open air outside the tube. The X-ray, on the other hand, is invisible. Many men of science created it on every occasion that they sent a current through a high vacuum tube. For the glowing ray from the cathode created an X-ray all the time it was striking against the glass sides of the tube. Yet the X-ray remained unknown and unsuspected, because it could not be seen.

But Professor Röntgen happened to be experimenting, towards the end of 1895, with a peculiar fluorescent screen on his laboratory table, used for studying the invisible ultra-violet element of sunlight. It was a screen made by coating a piece of cardboard with the tiny crystals of barium platino-cyanide. These crystals have the



THE WIRES THAT HELP TO MEND THE FRACTURED BONE OF AN ARM

THE RADIUS BONE OF THE ARM DISCLOSING A FRACTURE UNDER THE X-RAYS

peculiar power of changing invisible rays—that are too short to be seen by the human eye—into longer rays that are plainly visible. When the cathode glow was produced in the tube, the fluorescent screen shone out with a vivid brightness. The curious radiance might, of course, have been produced by the visible cathode rays; and this was the crucial point that Röntgen turned to settle. He covered the vacuum tube, so that none of the cathode glow was visible, yet the fluorescent screen continued to shine in the darkness with the new strange light. The Professor next placed various articles between the covered tube and the screen, and then the great discovery was made.

Some of the objects cast a sharp shadow, which showed how the wonderful new ray proceeded in straight lines from the walls of the tube. But other objects cast scarcely any shadow at all on the screen. The new ray went right through them. When, for instance, the Professor put his hand between the tube and the screen, he could see his bones through his flesh. So in the darkness of the laboratory of the Würzburg University there was made manifest Shakespeare's most fantastic idea that he puts into the mouth of Hamlet:

> "You go not till I set you up a glass
> Where you may see the inmost parts of you."

Thanks to the almost accidental discovery that Röntgen made by means of the screen used to reveal the presence of the invisible ultra-violet element in ordinary light, any surgeon can now say with truth to his patients what Hamlet in his frenzy said to his mother.

A TOY ANIMAL IN A CHILD'S STOMACH, PHOTOGRAPHED BY X-RAYS AT THE LONDON HOSPITAL

But before we deal with this interesting use of the X-rays, we must try to explain of what the strange and invisible radiance consists. It was at first thought that the new X-ray was one of the constituents of the cathode ray. It was supposed that part of the cathode ray stopped when it struck against anything, and that the other part went on and became the X-ray. It was here that the English men of science who still held, in spite of the discoveries made by Hertz and Lenard and Röntgen, to the theory of radiant matter were able suddenly to throw a blaze of light on the problem. For Professor Sir J. J. Thomson, of the Cavendish Laboratory, Cambridge, continued to experiment with the cathode ray. And in 1897 he discovered of what this ray consisted. He used a very high vacuum, so that the air still remaining in the glass tube was extremely rarefied. And he showed that when an intense electric discharge passed through this highly rarefied air it not only broke up the chemical molecules into atoms, but it exploded the atom, breaking it at times into things a thousand times smaller than the smallest atom. To these minute bodies, which he carefully measured in various ways, he gave the name of corpuscles. He found that they were composed of infinitely small centres of negative electricity, which are now generally known as electrons. Now, the cathode ray is a stream of these negative electrons. They are torn from the atoms of the rarefied gas in the glass tube, and then projected from the cathode at a speed about a third of that of light—say, 60,000 miles

X-RAY PHOTOGRAPH OF A GIRL'S HAND

This beautiful photograph, it will be observed, shows not only the bones of the hand, wrist, and arm two rings, a bracelet, and the button of the glove, but, in fainter outline, the flesh of the hand and arm

FACING PAGE 3245

a second. They can be twisted about and directed to any point, by placing magnets over the vacuum tube in which they are created. They respond to electric forces as well as to magnetic forces; and it was partly by measuring the degree of electro- ful discovery of the properties of the stream of swift electrons that form the cathode ray and create the X-ray. Working with Professor Collie, he took four vacuum glass tubes that had been so deeply stained by the creation of cathode rays and X-rays

THE APPARATUS AND METHOD BY WHICH AN X-RAY PHOTOGRAPH IS SECURED

The radiograph of the hand taken in the operation shown forms the subject of the plate to face this page

agnetic power that he used in twisting em from their straight path that Sir. J. Thomson was able to calculate the al- ost unthinkable minuteness of their mass. And just recently—in July, 1912—Sir illiam Ramsay has made another wonder- inside them that they were useless. The tubes were broken up, and the discoloured glass was heated, and nearly all the gases were condensed from it. Then the remaining gas was examined by spectrum analysis, and it was found to consist of helium—the

element given off by radium! So it looks as though the part played by the swift-moving atoms of helium in radium in disintegrating the elements on which they impinge is also played by the wonderful cathode ray.

In short, the cathode ray consists of the material substance of the universe in its ultimate form. It is electricity in a just sufficiently strong mass to act as a particle of matter. The chemist can take this book and analyse its substances, and then resolve these substances into their primordial elements. Then, in many cases, he can give a verifiable description of the arrangement of the molecules that compose the elements. And finally, as a matter of theory, he can analyse the molecules into atoms. But an atom of carbon still remains something different from an atom of hydrogen. When, however, the atoms of various elements are broken up in a vacuum tube by a discharge of electricity, there is no difference in the electrons that are torn from them. The electrons of a heavy gas have the same mass and velocity as the electrons of a light gas. We have got down to the fundamental, indistinguishable common stuff out of which, in conjunction with the electrons of positive electricity, everything material is made—our bodies, the frames of animals, all the substances of the earth, the sun, and the stars.


A RADIOGRAPH OF A DISLOCATED THUMB

Thus man has miraculously obtained, by means of a little empty glass tube, through which he sends a current of electricity, the power of resolving elements into the spectral whirls of electric force out of which everything material is built. That is why the apparently useless study of the conduction of gases has suddenly become the grand central point in modern physical science. The English school of physicists have triumphantly proved the correctness of the theory that the cathode ray was not a kind of electric wave, but actual radiant particles of matter in swift motion. And yet the German school have produced the man of genius who discovered the X-ray, on which the new ideas of the ultimate structure of the universe turn.

It may not yet be generally known that the X-ray and the cathode ray are found in radium and other radiant elements. But, as a matter of fact, this is the oldest discovery of the wonderful new ray. Nièpce, the inventor of modern photography, found as early as 1867 that salts of uranium, placed in utter darkness close to a photographic plate, left an impression upon it. Nièpce, however, was too far in advance of his time; and it was not until his discovery was again made by Becquerel in 1896, under the direct stimulus of Röntgen's achievement, that the search for radio-active elements was undertaken.

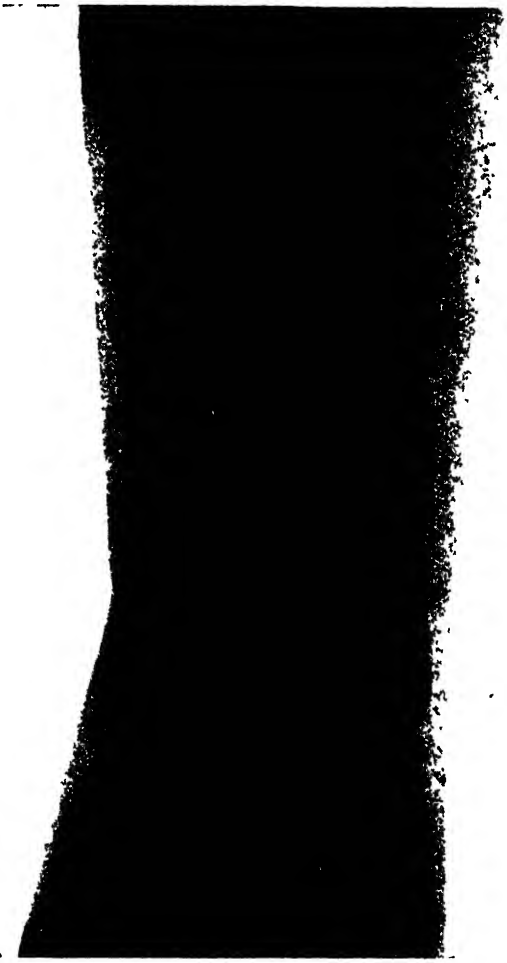
There is no essential difference in their nature between the X-ray created in a vacuum tube and the X-ray that is found in radium, in conjunction with other radiant streams. The only difference is one of speed. The artificial X-ray has a velocity of about 60,000 miles a second, while the X-ray that shoots out of radium has about three times this extraordinary pace.

The most striking thing about the X-ray is that it does not answer to any magnetic or electric force. It cannot be turned aside by means of electro-magnets. So it is clear that it is something quite different from the cathode ray that generates it. For a cathode ray can be twisted by means of electro-magnets round and round till it takes the shape of a coiled spring. Yet, as we have seen, the cathode ray is changed into an X-ray simply by striking on some object. And, what is still more wonderful, the X-ray can be re-transformed into a cathode ray by the same process. After shining through the atoms of various substances, it disappears, leaving behind it a cathode ray which inherits the energy of

the X-ray and continues its motion. It is thus a case of transformation and re-transformation; and the recent discovery of this amazing fact by Professor W. H. Bragg seems to throw a light on the mystery of the unknown radiation.

The older theory was that, when the particles of the cathode ray struck against anything, all their energy was transformed into a pulse of electricity. That is to say, a material thing was changed into an abrupt and curious electric disturbance, which resembled in essential character light, and yet possessed an intensity that enabled it to penetrate through various kinds of opaque and solid matter. This idea was put forward by Sir George Stokes and supported by Sir J. J. Thomson. But Professor Bragg has lately worked out a more fascinating idea of the nature of the marvellous X-ray.

He supposes that when the stream of negative electrons of the cathode ray strikes against the platinum point in the modern glass X-ray tube, it breaks up some atoms of platinum, and robs them of some of their positive electrons. Thus is fashioned a stream of doubled-natured bodies, consisting of the original negative electrons, to each of which is attached a small charge of positive electricity. And this is the X-ray. Being neither positive nor wholly negative, it does not answer to an electro-magnet. And, moreover, it is not impeded by the electrical attractions of the atoms through which it passes on its shining march through matter. We must remember that an atom consists of an empty space—somewhat like our solar system on a very small scale—in which a few infinitesimal negative electrons are spinning round a large positive electron. There is therefore at times ample room for the X-ray to pass through atom after atom, throwing on the screen only a faint shadow of the substances through which it swiftly travels.



A BROKEN LEG, SHOWING HOW THE TWO BONES HAVE BEEN FRACTURED

Yet, sooner or later, there is a collision. One of the results is that the X-ray is robbed of its stolen property—its positive electrical charge—and reduced to its original character of a cathode ray. The same thing happens with the X-ray that proceeds from radium. As its speed slows down, just before its work is done, it becomes a cathode ray of negative electrons, with a diminishing energy of velocity; and at last its particles penetrate into an atom from which they have no longer the power to emerge. And that is practically the end of it. It is absorbed in the existing and permanent structure of the universe—in the gases of the air or in the atoms of the walls, ceiling, or floor of the room in which the X-ray apparatus is being used. Such is the gist of Professor Bragg's theory.

Unfortunately, from a medical point of view, when the X-ray comes to an end in human flesh and is re-transformed into the original cathode ray that produced it, it often may have a serious effect upon the flesh of the X-ray operator. It breaks up the cells of that part of the human body on which it has been constantly falling. The consequence is that dreadful sores are sometimes formed upon the hands of an operator who is continually exposed to the

TWO VIEWS OF THE DIGESTIVE TRACT THROUGH WHICH MAN'S NUTRIMENT PASSES—

X-rays. Even the constant study of the action of X-rays by means of a fluorescent screen hurts the eyes of an operator, causing an inflammation of the outer portion of the eyeball. The fact is, the X-ray is so intense a form of energy that it gives rise to what are called secondary radiations. It breaks bits off the atom against which it strikes continually; and when these atoms are the elements of substances in the living flesh of the X-ray operator the result is at times serious.

Several brave men who worked the X-rays in hospitals, with great benefit to thousands of injured patients, have now lost their fingers, hands, or arms through the strange, spreading, and terrible sores produced by continual daily exposure to the extraordinary power of the X-rays.

Yet it must not be thought that a patient

RADIOGRAPHS MADE POSSIBLE BY FEEDING THE PATIENT ON A FOOD CONTAINING MUCH IRON

nowadays is in any danger when the X-ray is used upon him by a skilled operator to find some broken bone, or some diseased organ, or some foreign body, such as a needle or bullet that has got embedded in his flesh. If a very long exposure of some hours is necessary, his skin may feel a little sore, but the soreness will pass away. It is only the heroic operator, day after day exposing himself to the weird force of the ray, who is in peril of great and permanent injury. In an ordinary way the action of the ray on human flesh is said to be often beneficial. There is, for instance, an ulcerous disease of the skin produced by the same tubercle microbe that causes consumption of the lungs. A careful application of the rays brings about an inflammatory reaction, which causes the tubercles to become visible. This is

followed by a loosening of the tubercles; they are then sloughed off in masses, and a healthy scar tissue grows underneath.

A similar beneficial result is often produced by means of the Finsen light, but the X-rays are quicker in action, and less expensive in use, and they can be applied to cavities which are inaccessible to the Finsen light. Several other skin diseases and various kinds of malignant growths have been cured by treating the sufferers with X-rays. Some cases of cancer of the throat and breast are reported to have been cured by applications of the rays, lasting for ten minutes, and repeated daily for some weeks. But on the whole it seems that the new treatment is only likely to be successful in diseases affecting the outer parts of the body that can be directly subjected to the action of the rays. When the malady is deep-seated, the healthy surrounding portion of the body tends to become seriously inflamed by the rays as they pass through on their way to the seat of the disease.

X-RAY TREATMENT FOR CANCER AT THE MIDDLESEX HOSPITAL

At the present time there are several means of protecting an operator from the action of the rays. In some cases, he needs only to use a very mild form of the new power. This is obtained by allowing a certain amount of gas to enter the glass tube, and so lower the vacuum. The ray then produced is very soft; it cannot penetrate far. Hard rays, on the other hand, are got by increasing the vacuum and making the air in it more rarefied. When this is done, the operator has to be careful to protect himself. There are two principal methods of protection. In one, advantage is taken of the fact that the X-ray cannot penetrate lead. So a lead-glass is placed over the vacuum tube, leaving only a small point in the inner soda-glass vessel through which the X-rays stream on to the patient Again, the operator now has various devices for testing the strength of the rays, without putting his own hand between the stream of invisible force and the screen, in order to measure the penetrative-power. This rough-and-ready manner of testing the rays was the chief cause of the loss of fingers, hands and arms by the band of brave men who first worked the rays. The modern operator measures the power of the radiance he is about to apply to a patient, by means of curious and delicate instruments that show the amount of electricity the invisible ray is communicating to the air outside the tube. The degree of electrification exactly denotes the softness or hardness of the unseen radiance; and a careful operator never now exposes his eyes or his hands to the action of the unseen force. During his work he uses rubber gloves, and puts on a pair of lead-glass spectacles, and wears a rubber apron.

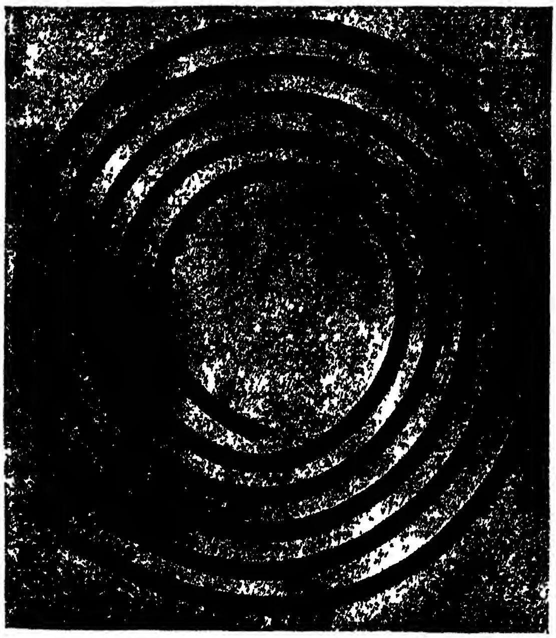
But the most effectual way of sheltering the operator from daily contact with the rays he is using is to divide the X-ray room of an hospital into two parts, separated by a leaden wall. In the inner chamber is a vacuum tube fitted over a comfortable seat or bed for the patient. The patient is placed in position, and told not to move, and then the operator retires and closes the leaden door, and goes to the instrument that sends an electrical current into the inner chamber and produces the cathode glow in the tube. Very often he has merely to set a clock going to make the current flow for exactly the time necessary. And just above his head is a mirror that reflects the vacuum tube, the part of the patient's body that is being treated, and the image on the fluorescent screen produced by the X-rays. By this

CONTROLLING POWERS OF DESTRUCTION

X rays not only act beneficently as powers of destruction but they also act malevolently on any [illegible] are in frequent contact with them. Consequently patients treated by X rays are isolated in a [illegible] lined chamber, through which the rays cannot pass and the doctor watches the patient through a window of lead glass

ingenious system of a double-chambered X-ray room and a mirror, the operator can undertake every day a great number of cases, without feeling any injurious effects from the continual and subtle influence of the radiance on his own body.

His work has, moreover, been greatly lightened by the progress made in X-ray photography. In a general way, the invisible radiance that penetrates through flesh and bone is employed for finding out what is the matter with the patient. This can be done much quicker by means of photographs of the interior of the human body than by studying the actual picture thrown on the fluorescent screen. For the photographs can be minutely examined in broad daylight and at leisure, and compared with similar photographs of the flesh and bones and organs of healthy people. For this reason X-ray photography has become, both for the surgeon and the physician, the most important by far of the medical applications of the new force; and inventors are still busy in perfecting this branch of radiography.



THE VALUE OF X-RAYS TO THE MANUFACTURER

A radiograph of a length of cordite taken to detect possible faults in its structure

At first there were obtainable only flat silhouettes of the shadows cast by the X-rays as they travelled through the human body. By using just a medium hard ray, which did not penetrate through the bones, the skeleton of the human frame could be shown in dark shadows amid the lighter, vaguer tints of the flesh. The method was useful in discovering fractures of bones and foreign bodies of metals, such as bullets and splinters of shell in wounded soldiers, and needles and nails and other metallic objects due to domestic and industrial accidents. It was early shadow-photographs of this sort that directed the general attention to the wonderful properties of the X-rays in the first years following their discovery.

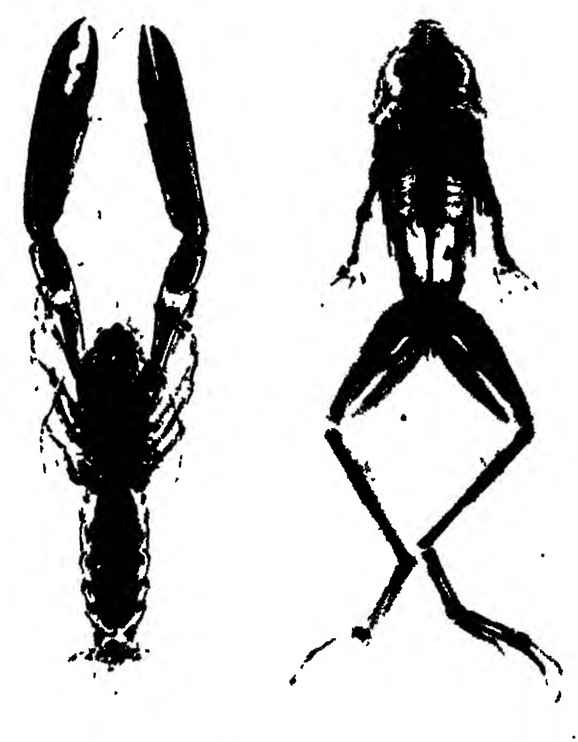
But the trouble with a flat shadow-photograph was that it gave no indication of depth. It only showed in outline the internal structure of the human body. In the case of fractures of bones, this difficulty was overcome to some extent by taking several photographs—from the sides as well as from the back and front of the injured limb or other bony part. So the surgeon was fairly well contented with a series of flat silhouettes that the X-rays gave him.

It was some time, however, before the new invisible force, that can penetrate wood and steel, was of much use to the physician. In many cases he required a clear and perspective view of the flesh organs and of the softest parts of the tissues. And this is what he has now obtained. By using soft rays on certain parts of the body, and taking two separate photographs, and combining them for examination in a stereoscope, he can often get a perspective vision into the human body. Everything stands out in order in soft relief, so that various diseases of the lungs and heart and other organs can be traced. And there is another more technical method, called plastic X-ray photography, which gives similarly excellent results. All this is a magnificent advance in the art of locating the effects of a malady and observing exactly the results of a curative treatment. The physician can see with his own eyes the improvement that is taking place, or the need there is to adopt some other form of cure. Moreover, he can give the patient certain bismuth preparations that will coat some of the interior parts of the body, and make them stand out very vividly in a stereo X-ray photograph or a plastic X-ray photograph.

Just recently, an extraordinary application of the medical use of X-rays has been made by converting the human body into

a fluorescent screen. It has long been known that a natural fluorescence existed in certain human tissues, and that the nerves, muscles, and brain, and the chief organs, contain a fluorescent material that resembles quinine. Now experiments are being made in dosing patients with quinine preparations, and then making the medicine shine in the body by applying X-rays to the part that is diseased. Some good results are reported to have been obtained in certain tuberculous maladies. It is too early yet to give a reliable decision on the general value of the method.

Indeed, much yet remains to be done before the various forms of X-ray treatment and examination are perfected. At present tumours of soft tissues are photographed with great difficulty, owing to the surrounding structure having nearly the same density. Diseases of the brain are especially hard to trace by means of the X-ray. For the shadows of the bony vault of the head greatly obscure the details of the soft structure. And, moreover, as the rays pass through the skull, they produce cathode rays that tend still further to confuse the shadowy image of the brain. Yet already a blood-clot in the brain has been revealed by the wonderful ray. So we may expect the intricate technique of the modern operator to be at last developed to a point at which the entire internal parts of the bodies of suffering mankind will be made clearly visible to the modern physician.



CRAYFISH AND FROG SATURATED WITH OIL AND PHOTOGRAPHED

What has already been accomplished is so wonderfully useful that it is revolutionising medical science. In course of time every surgeon and doctor will be an expert X-ray operator. He will begin by studying the healthy functions of the body with a fluorescent screen and the X-ray stereoscope. Then he will go on to learn all the signs of hidden diseases that the X-ray reveals. So, when he is fully trained, he will be able to tell, almost at a glance, what is wrong with his patient. In the meantime, the new scientific blood-tests, by which the cause of a disease is revealed under a microscope, will be extended and in many cases simplified. So there ought to be in the future no occasion for a careful medical man to make any mistake in his diagnosis of an illness. The healing art, that still remains an art, will then be transformed into a science; and this science will grow more exact as man obtains a larger control over the microbes of disease.

Speaking from his own point of view, the writer is doubtful of the value of the X-ray in directly curing diseases. It may, in some cases, do good by setting up an inflammation, and thus determining a flow of blood to the sore part. Or it may burn off some diseased part of the skin, and, in favourable circumstances, allow a healthy scar to form underneath. But this is a very violent form of treatment, that seems scarcely better than searing or corroding with a hot iron or nitrate of silver. More gentle and more generally effective forms of treatment are now being worked out. So we incline to the opinion that the X-ray will be found permanently useful in its marvellous revelation of the interior structure of the human body. We may add that nobody should submit themselves to the action of the X-ray, whether for treatment or for examination, except at the hands of a skilled operator.

A HERD OF DAIRY CATTLE ON A HAMPSHIRE FARM SUPPLYING MILK FOR LONDON

A HERD OF DAIRY CATTLE AT GUNDAGAI, NEW SOUTH WALES

THE DAIRY INDUSTRIES

How the Vigorous Lactic Germs are Controlled and Set to Work

SCIENCE IN MAKING BUTTER AND CHEESE

In no industry of wide importance has the application of scientific methods produced so thorough a revolution as that which is taking place in the milk and milk product trades. We are still far from having brought the revolution to a successful conclusion, and it seems probable that legislation, and Government supervision will be necessary to transform all the dairy industries of our country into sources of pure and healthy foods. Yet much has already been done to improve and regulate the conditions that are partly responsible for the death of many children and the spread of tuberculous diseases.

The dairy industries are the most difficult of all large enterprises, by reason of the part played in them by various kinds of microbes. In both butter-making and cheese-making the presence of germs that set up fermentations is absolutely necessary. On the other hand, the action of these germs has to be stopped in milk that is used for food in the ordinary way. For if the action of the ferment is not stopped, the milk rapidly becomes sour. It will thus be seen that the dairyman has many special difficulties to contend with. The progress that he makes depends almost entirely upon advances in scientific investigation, and the invention of new kinds of apparatus based on these investigations. Hence the study of the milk industries has a special interest for all persons interested in the ideas and methods of modern science.

The position that the small country of Denmark now occupies in butter-making is due to the efforts of two Danish men—N. J. Fjord and J. C. la Cour. By the researches and inventions of these two patriotic and gifted Danes, and by the splendid organising power that they displayed, a little people of peasants, who were little more than serfs a hundred years ago, has been enabled to become the most prosperous and enterprising race of dairy farmers in the world. On the one hand, they have solved the great industrial problem of modern times, by showing how men of small means can combine into an organisation more powerful than the wealthiest of Trusts. And, on the other hand, they have proved how marvellous is the force of scientific knowledge when it is properly applied to an ancient and apparently settled industry.

Even in its old form a dairy is an extraordinary example of the power of man. In a wild mammal in a state of nature, milk is secreted only in an amount sufficient for the needs of her young, and the supply lasts simply for the short period in which the offspring is unable to secure food by its own exertions. But by slow degrees man has turned the milch cow from her natural function, and transformed her into a kind of living machine for the production of milk. Not only has he increased the amount of the flow, but he has lengthened the time during which the cow secretes milk until the supply is almost continuous. This has been done mainly by breeding from the best milkers, and so profiting by every useful variation in the cattle connected with a larger abundance of milk.

Thus it comes that man has practically created a new kind of animal, from which he can obtain at times 14,920 pounds of milk every year, yielding 1103½ pounds of butter and a large quantity of skim-milk and buttermilk. This was obtained from a Guernsey cow, 9½ years old. If her year's supply of milk is reduced from pounds to gallons, it works out at about 1492 gallons for the twelve months. Almost all this would be available for human consumption if the milk were made into butter. For her calf could be fed on the skim-milk, supplemented

by some cheap fat food. So nearly all the product of the little living milk machine would be available for human use. Is not this a wonderful example of man's power over the life that surrounds him?

Though the milch cow shows his strange power at its highest, there are many other large female mammals from which he obtains supplies of milk. The Laplander keeps to the reindeer that man probably domesticated in the Old Stone Age. The Tartar gets milk from his mares, and the Bedouin from his camels. In rocky lands a she-goat is an admirable little milcher. Asses' milk is still supplied to invalids, and in tropical swamps and jungles the female buffaloes provide the natives with good milk. The milking of ewes is largely practised in certain parts of France, especially for cheese-making. Ewes, for instance, are kept as dairy animals in the department of Aveyron, and the famous cheese obtained from their milk is cured in the limestone caves in the mountains around the village of Roquefort. The milking of ewes was formerly common also in England, but it has

PRIMITIVE MILK-MAKING—CHURNING IN A GOATSKIN AT BEEROOTH, PALESTINE

A DANISH DAIRY FOR NATURAL PURE MILK

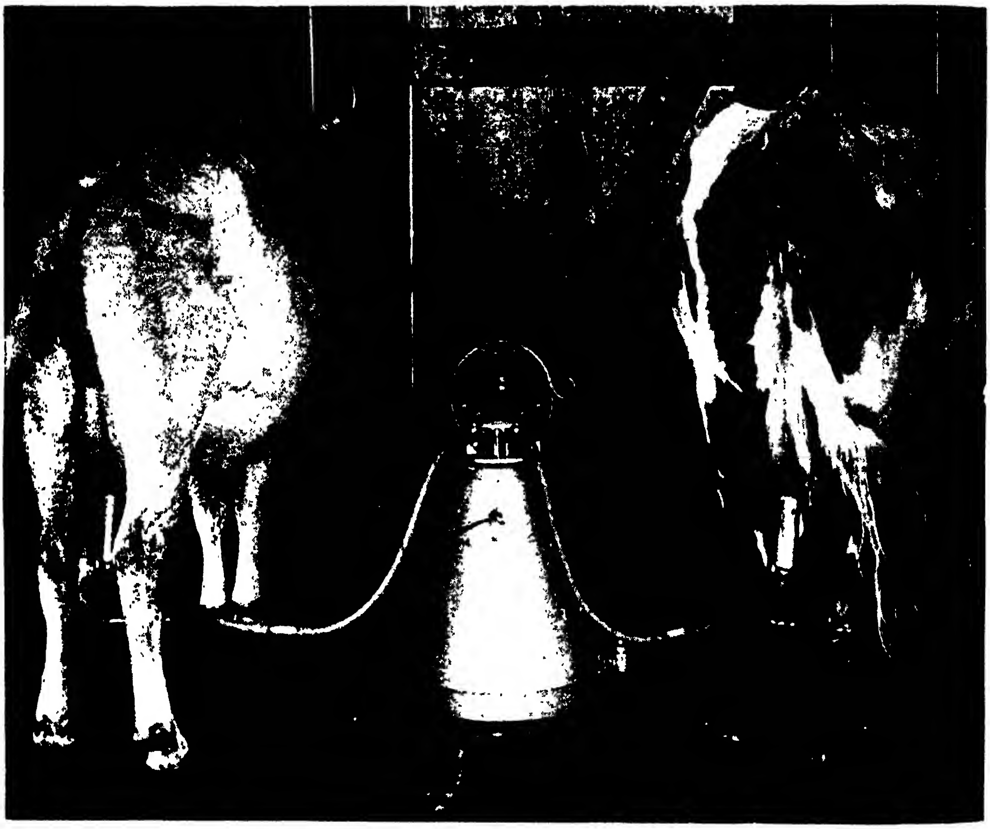
...Denmark pure milk is delivered successfully in its natural pure state. This is effected by ...ing inspected cows in the open air, after washing their udders, and not using the first ... of milk. The pail used has a double bottom, enclosing ice, so that the clean milk is kept at ... temperature in which organisms will not develop, and it is thus delivered cold to the customers.

- V

been discontinued on account of its effects upon those qualities of the flock which are now more prized than the milk obtained from the ewes.

The fact is, the modern milch cow is now so wonderfully specialised for her work that the milk industry is practically based entirely upon her. In some ways this is unfortunate, for the milk of the she-goat at least has some very valuable qualities of its own which make it, in certain cases, preferable to cows' milk. But leaving this point for later discussion, and accepting the fact that the dairy industries now turn entirely upon the milch cow, we will endeavour to trace the progress that has been made by the application of new scientific methods. The extraordinary growth in the number and size of our large industrial cities has brought about some difficult problems in the milk supply. In the County of London, for instance, there are now comparatively few dairy farms; for milk can be delivered in the metropolis from distant parts at a lower price than it can be produced in the pastures around the enormous city that consumes eighty million gallons of milk a year. The increasing cost of labour and the enhanced value of land in the County of London have compelled the milk-traders to go farther afield in their search for cheap supplies of milk.

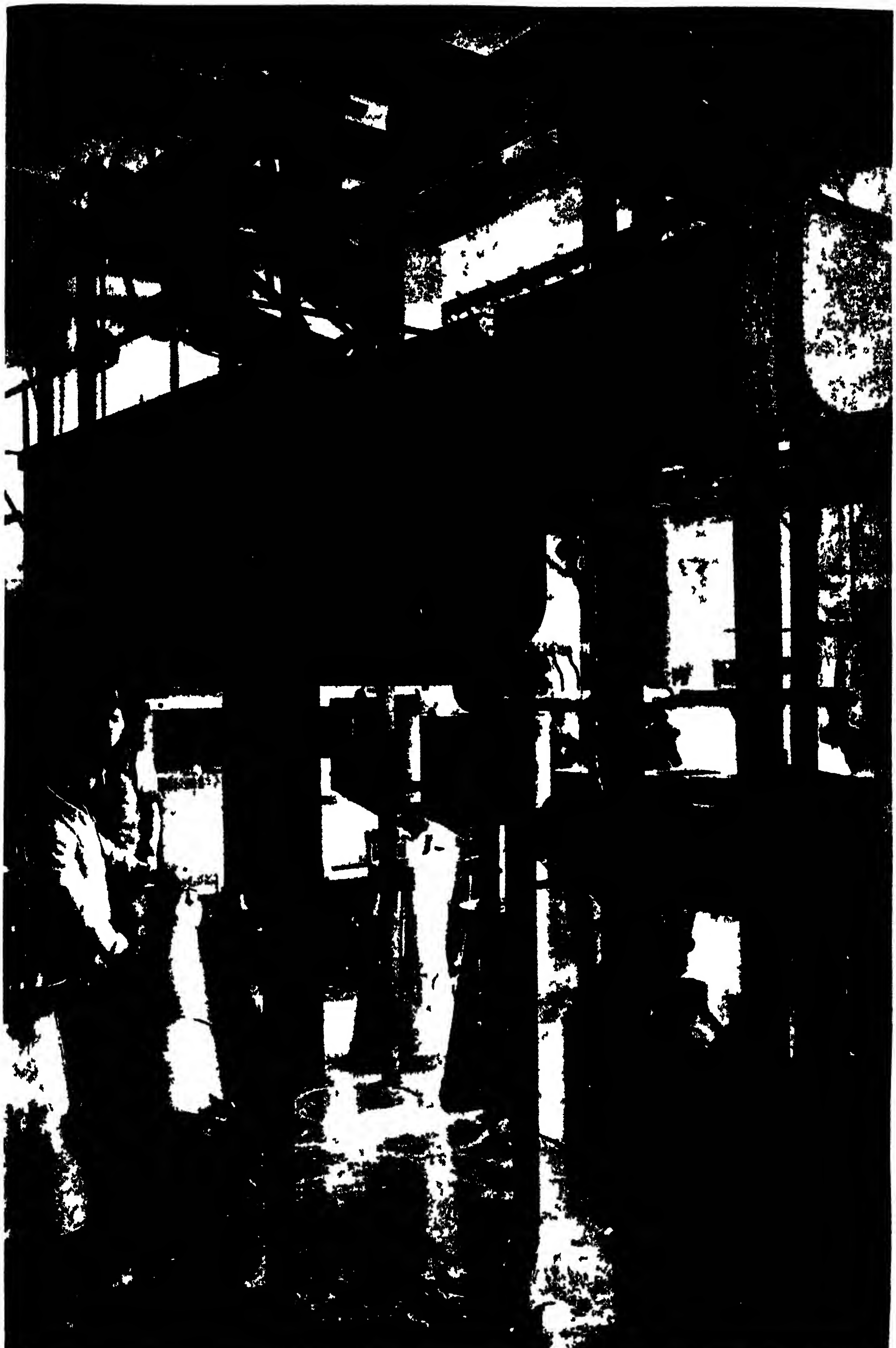
And, helped by the facilities afforded by railways and favourable rates of transport, the dairy farmers for about two hundred miles around London so control the milk supply that they are in the happy position of being exempt from foreign competition. The foreigner can compete only by condensing his milk by evaporation, and sending it in air-tight cans. On the whole the British dairymen have won their control of the situation by fair means and enlightened methods, though there is room for further improvements in the general conditions under which the milk is supplied to householders.



THE HYGIENIC METHOD OF MILKING BY MACHINERY

As the average yield of each cow is about 500 gallons of milk a year, 160,000 cows have to be milked night and morning for the benefit of the people of London. Some of the farms are as far north as Derbyshire

MACHINERY TO THE AID OF THE MILKMAN



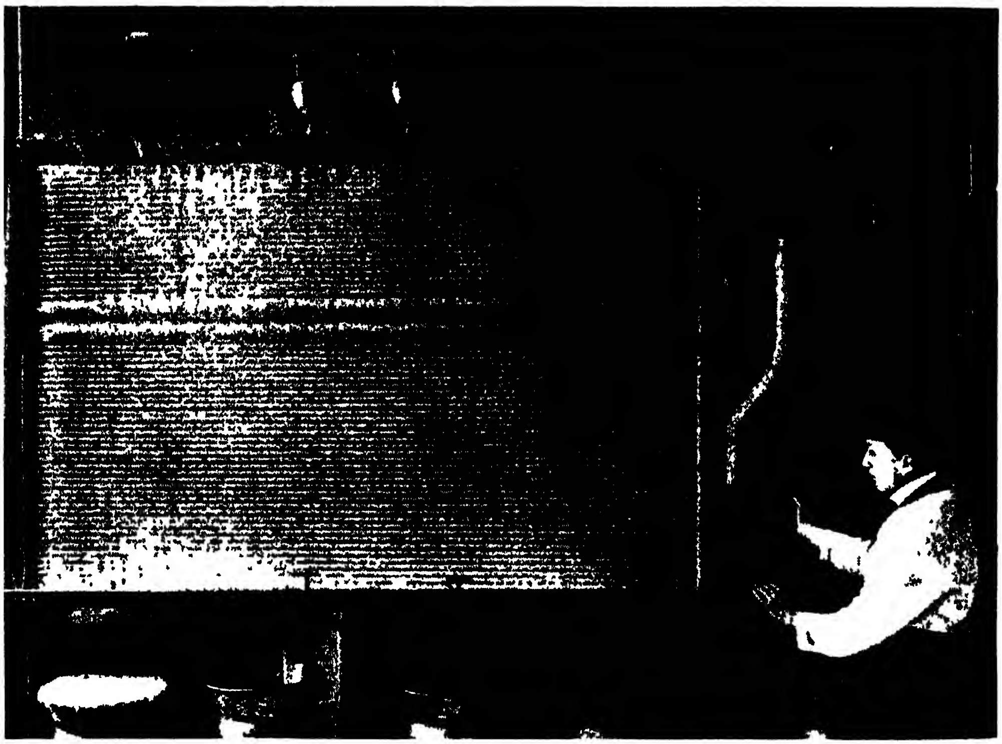
APPARATUS FOR HOISTING CANS AND MEASURING MILK AT A LARGE LONDON DAIRY

The photographs on these pages are by courtesy of Messrs Welford & Sons Ltd The London Pure Milk Association, and The Governments of New South Wales, Victoria and New Zealand.

and as far south as Dorset. There thus arises the problem of protecting the milk from souring on its journey, through the natural lactic germs that at once begin to work in it as it comes from the cow. This protection can only be secured by absolute cleanliness in the first handling of the material, and by keeping the milk so cold that germs cannot multiply in it. Practically all the troubles of an exporting dairy farmer would be overcome if he had a fairly cheap and simple machine for extracting the milk from the udder of the cow into an air-tight can. For, except in the case of animals suffering from disease, the milk is almost germ-free when it comes from a cow. But many mechanical milkers have been invented which have the defect of being less efficient than the hands of the human milker.

Yet recently a vacuum-pump method has been adopted in some large American dairies, which promises to make machine milking a practical success. It can be worked by a motor, as is done in large milk factories, or by a treadmill to which a horse or bull is attached. It consists of a vacuum pump, connected by an iron pipe to a vacuum tank, with attachments running into the barn where the cows are milked. The barn pipe runs above the cow-stalls, and from it hang rubber tubes connected with an instrument over each milk-pail. From the milk-pail run rubber pipes, ending in rubber cups that fit over the four teats of each cow. The instrument over the pail is called a pulsator, and by means of the vacuum it alternately draws and compresses the cow's teats, being managed and regulated by two stop-cocks.

Each mechanical milker—consisting of milk-pail, pulsator, rubber connections, and teat-cups—is capable of milking two cows at the same time. Tiny glass windows in the tubing allow the operator to measure the flow of milk. By means of the machine, one man can do four men's work, milking from thirty to forty cows an hour. Moreover, the results are much more uniform. Daily variations in the milk yield, depending on the personality of the milker, are avoided, and, what is of public importance, there is no initial contamination of milk. The entire cost of the installation, power and milking machines, amounts to about £2 8s. a cow for a herd of forty cows, and £1 13s. a cow for a herd of seventy-five. Already the widespread doubts as to the amenability of cows to the milking machine, and as to the danger of drying up cows from

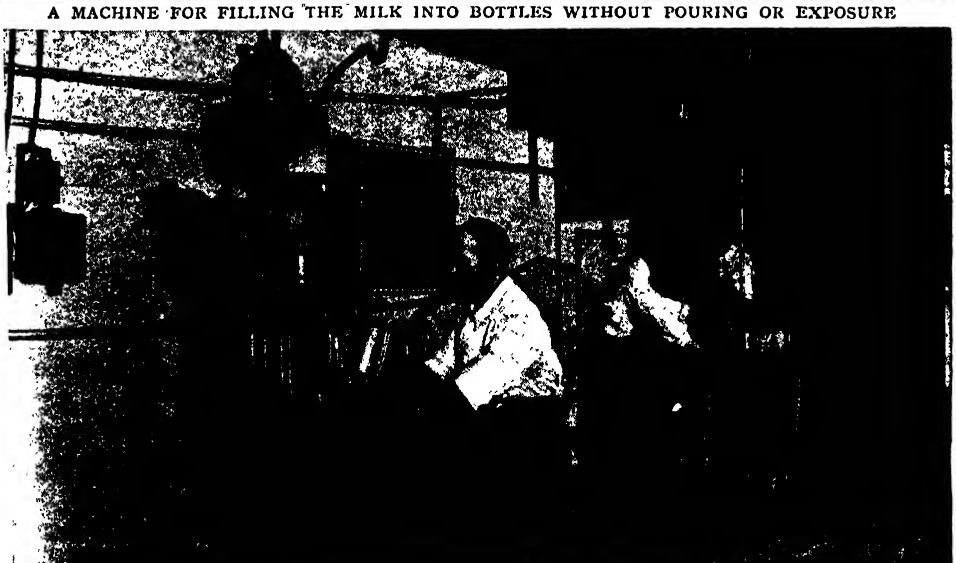


CHILLING MILK TO A TEMPERATURE OF FORTY DEGREES BY REFRIGERATING MACHINES

THE HYGIENIC DISTRIBUTION OF MILK

GENERAL VIEW OF A WORKING DAIRY THAT SENDS OUT ITS MILK IN BOTTLES

A MACHINE FOR FILLING THE MILK INTO BOTTLES WITHOUT POURING OR EXPOSURE



A MACHINE FOR CLEANSING WITH STEAM BOTTLES IN WHICH MILK HAS BEEN DISTRIBUTED

incomplete emptying of the udder, have been dispelled. Animals hitherto unruly to hand milking, and heifers never milked before, have taken kindly to the machine. So that it looks as though machine milking will prove, on the whole, better than hand milking. For it is said that cows that are machine milked have a longer period of lactation than hand-milked cows. In thirty comparative tests between hand and machine milking, the number of germs present in the milk was reduced by a full half by the use of the machine; and the milk was generally much cleaner.

In hand milking it is practically impossible to prevent milk from becoming contaminated with foreign substances. This happens even in very clean dairies, where the milkers scrub their hands and wear spotless overalls when working over the milk-pail. The dirt, however, can largely be got rid of by passing the milk through strainer cloths, which must be sterilised by boiling before they are used. When this straining process is carried out properly, it is more effective than putting the milk in a separator and whirling it until the heavy foreign matter is thrown against the sides of the machine. No straining process, however, frees the milk from any of its germs. For the germs are so small that five hundred millions of them may exist unseen in a quarter of a teaspoonful of milk.

They can be detected, however, by the taste, when they exist in very large quantities. And long before Pasteur showed that the acidity was due to the presence of fermenting microbes, the dairyman found a method of keeping milk fresh for some time by cooling it. He did not know that he was dealing with the fermentative action of living but invisible forms. Nevertheless, he discovered how to impede their action, simply by cooling milk over running water and keeping it in a cool place. And what he did without knowing what he did, his more enlightened successors perform in an exact and scientific manner. They know that the most favourable temperature for the growth of disease germs is that of the animal body—98 degrees to 103 degrees F.; while most of the other germs in milk multiply at a considerably lower heat from 59 degrees F. to 77 degrees F.

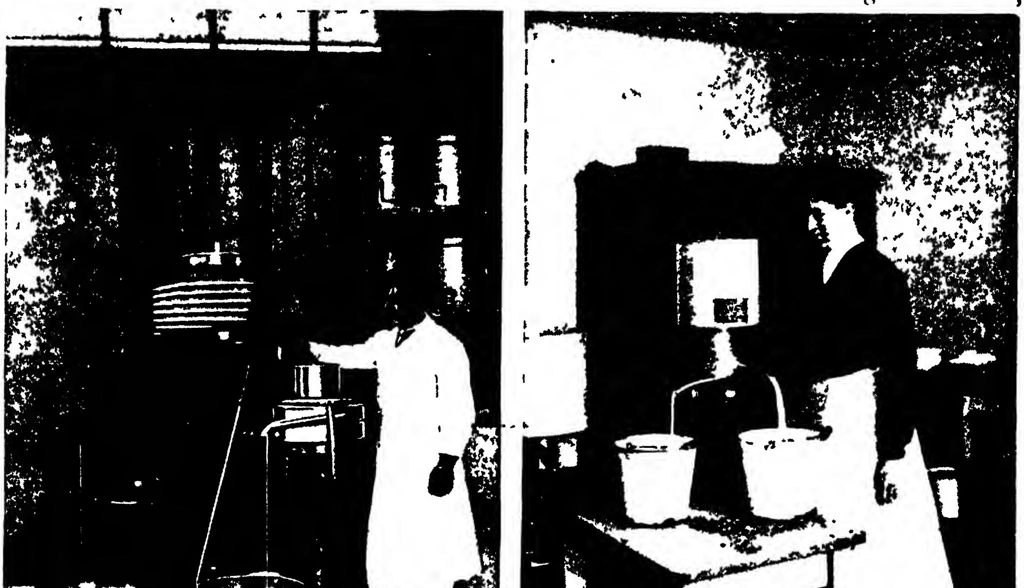
This second class of germs has sometimes to be encouraged and sometimes to be repressed. They are needed in butter-making and cheese-making. But their presence in ordinary milk is undesirable, because they are the agents that break up

THE BOILING AND STERILISING ROOM AT A COUNTRY CREAMERY

the sugar of milk into the acid that produces a sour taste. There are two ways of dealing with these lactic acid germs. They can be killed by boiling the milk, or they can be kept from multiplying for some time by means of a low temperature. Milk that is sterilised or pasteurised by great heat is not altogether healthy. It is particularly unsuitable for children, and no baby should be brought up on pasteurised milk. Anæmia, rickets, and malnutrition occasionally develop in infants fed on boiled or pasteurised milk. For certain ferments or germs are present in cows' milk which help in the digestion of food, and these ferments are destroyed by great heat or by repeated application of mild heat. So, all round, clean unheated milk from herds that are periodically tested in a scientific manner for infectious diseases is much to be preferred to milk that is artificially sterilised.

In practically all dairies in which milk is prepared for long journeys to large towns the cooling method is employed. After being strained, the milk is run into a cooler, and there, by means of cold flowing water or some refrigerating apparatus, it is lowered to a temperature at which the acid germs are scarcely able to multiply. All the vessels in which the milk is placed for preparation or transport are sterilised, steaming being the easiest way of doing this on a large scale. Then, if the filled churns are kept cool on the railway train, the milk can be sent for a long distance without growing unwholesome or altered in taste.

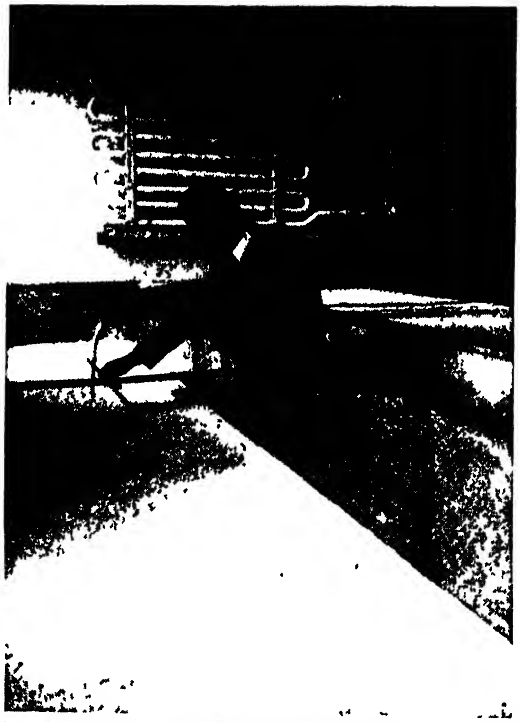
The chief source of contamination of good and well-cooled milk is the open churn that the city milkman uses on his rounds, and the metal cans in which he delivers supplies to his customers. The dusty and germ-laden air of the streets gets into the milk, not only causing it to sour quickly in all cases, but infecting it at times with floating microbes of disease. As things now stand, it is best for everybody to insist upon their milk being delivered to them in the cardboard-covered bottles that are now being largely used by reputable milk-traders. But even these bottles are far from being a perfect protection against the ubiquitous germ. The ideal condition of things would be for the milk to be obtained from the cow by a milk machine, and passed through the strainer into the cooler, and thence run into the new paper milk-bottle that is coming into use in America. The paper bottles do away with the breakage, the cleaning, the sterilisation, and the loss incurred in collecting empty milk-bottles. In the quart



TWO TYPES OF MACHINES THAT SEPARATE CREAM FROM MILK

size they weigh only two ounces, as against the twenty-four and twenty-six ounces of a glass bottle. They cost about a halfpenny for a quart, and they are absolutely germ-proof.

The farmers, middlemen, and retailers might manage to save the expense of the paper bottles by putting the milk straight into them from the cooler, and thus avoiding the churns and all the expense and labour of the washing and sterilising outfit now required for glass bottles. For the paper vessels could be packed in light, open boxes for transport. They would only need to be kept cool, for the customer to receive the milk in the sweet, clean, wholesome condition in which it left the distant dairy farm. We must, however, admit that we have had no practical experience with the paper bottle. Our remarks are taken from a report made by Dr. A. H. Stewart in an American journal of hygiene, "Sanatation." But if the tests to which Dr. Stewart submitted the new paper bottle are fulfilled in ordinary work, the grave social problem of a pure milk supply will be practically solved in the immediate future.



CREAM IN VATS AT AN AUSTRALIAN BUTTER FACTORY

But, to any enterprising man with children to bring up, and a small garden to his house, we should like to recommend a little domestic experiment in the milk industry. In a family of young and growing children, the bill of the milkman is a large item in the weekly account. With a small outlay of capital this expense may be largely avoided. For an Anglo-Nubian she-goat can be kept healthy and profitably in a small yard or a bit of a back garden. She wants some good oats and bran, and some mangolds in winter, but the cost of her keep is not great. For all the waste kitchen green-stuff is excellent food, and potato-peelings and odd bits of bread and biscuit are turned by the Anglo-Nubian into superb milk. For a small consideration, the neighbouring greengrocer will readily give the amateur goatkeeper the waste from his shop.

The great thing about the milch goat is that she is not liable to the common bovine disease of tuberculosis. Her milk is absolutely the safest food that can be given to children, and we should like to see a large industry developed from it. In England, cows' milk is of the legal standard when it contains 3 per cent. of cream fat—most cows' milk contains 4 per cent. of this fat: but unscrupulous persons can reduce this quantity without being condemned as adulterators. Goats' milk, however, contains about 8½ per cent. of cream, more than double the amount derivable from cows at the dairy shows. And not only is goats' milk much superior in cream, but it contains also larger quantities of curd and more bone-forming material. The she-goat has no odour, and her milk is not only rich but pleasant to the taste; and as she requires no more care and no more room than a few chickens, there is no reason why she should not become the domestic milk supplier to a large number of our people.

From the point of view of the national health, the milk-supply trade is of the highest importance, but it has less scientific interest than the butter and cheese branches of the dairy farming. For it is a fairly simple matter to repress the activities of the lactic acid germ; and the world is only waiting for a cheap domestic refrigerator to solve the problem of keeping the milk fresh in the house during the hottest or closest summer day. In butter-making, however, it is necessary to allow the lactic germs to ferment, and yet to control their marvellous activities in such a way as to produce a wholesome and palatable article of food. As is well known, good milk consists of a large quantity of water containing about

BUTTER MAKING IN FARM AND FACTORY

BUTTER MAKING AT A SMALL FARM—THE OPERATIONS OF CHURNING, ROLLING AND WORKING UP

BUTTER MAKING ON A LARGE SCALE WITH THE AID OF MECHANICAL POWER

CREAM BEFORE AND AFTER REVOLUTION IN A CHURN

BUTTER IN A MECHANICAL WORKER

4 per cent. of fat, 4 per cent. of curd, nearly 5 per cent. of sugar, and a small quantity of mineral matter. Altogether, there are about thirteen parts of solid matter and eighty-seven parts of water in every hundred parts of milk.

The lactic fermentation is produced by the action of the lactic germs on the sugar. They decompose each molecule of sugar into four molecules of lactic acid. If yeast is introduced into the milk instead of the usual lactic germs that introduce themselves, the sugar can be changed into alcohol; this is the way in which the slightly intoxicating koumiss, used by the Tartars, is now produced from cows' milk. Butter, on the other hand, seems to have been first made by allowing milk slightly to sour in the usual way, and then shaking it up in the skin of an animal. By this means the small globules of fat in the milk are slowly brought together and made to cohere in large masses, so that bits of butter at last occur in the fluid. But this method of primitive times is extremely slow, laborious, and wasteful. Butter-making did not become an art until some unknown man or woman of genius found a way of collecting the fat or cream of milk, by allowing the liquid to stand for some hours in shallow pans, and then skimming off the cream, and putting this in a butter-churn. Such is the traditional method that is still followed by old-fashioned farmers' wives who make butter in small quantities for home use. Butter-making did not become a science until about 1880, when the mechanical cream-separator began to come into general use. And another ten years passed before it was possible for small farmers to combine fairly in large co-operative butter factories, and prevent individual members from lowering the general standard of the butter by supplying inferior milk. But in 1890 a device for quickly measuring the cream or fat contents of the milk supplied daily by each dairy farmer was invented. The result was that co-operative butter-making and large butter factories were provided with a means of maintaining a rigorous standard in the quality of the milk.


WHEY AS A FOOD FOR PIGS

In short, the separator and the cream test are the foundations of the great modern industry of factory-made milk products. And it is chiefly because the dairy farmers of the United Kingdom were at first backward in profiting by modern methods of manufacture and modern methods of organisation that Denmark captured the bulk of the butter trade and the bacon industry, that largely depends on the by-product of skimmed milk. Bacon, that was formerly one of the cheapest of meat foods, is now one of the dearest, partly because our dairymen have had to specialise in the fresh milk trade, leaving the foreigner to supply our country with £24,500,000 worth of butter at a good price. For this enables him to build up a vast bacon industry cheaply out of the enormous quantity of skim-milk that remains on his hands after the butter is made.

There is a widespread mistake concerning the food value of the skim milk obtained from the modern separator. It is true that separated milk contains scarcely any fat. From the butter-maker's point of view, this is a chief advantage of the separating machine. When the milk is placed in it, the separator revolves with a speed of five thousand revolutions or more a minute. The consequence is that the heaviest elements in the milk are driven by centrifugal force outward, to the sides of the machine. Now, the cream or fat of the milk is lighter in weight than either the watery fluid or the curds and other solids. This is seen when a glass of fresh milk is allowed to stand for a time. By mere gravity the water and curds sink, and allow the lighter cream to rise and settle on the top. In the

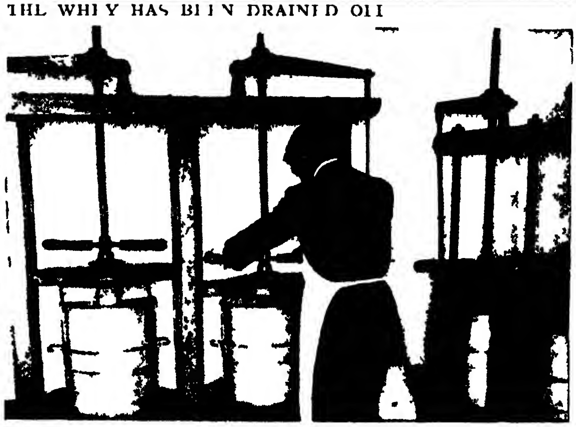
SOME PROCESSES IN CHEESE-MAKING

ADDING RENNET TO COAGULATE WARMED MILK

CUTTING THE CURD TO REMOVE THE WHEY

GRINDING CURD AFTER THE WHEY HAS BEEN DRAINED OFF

CLOTTING THE GROUND CURD BEFORE PRESSING



PRESSING THE CHEESES TO SQUEEZE OUT WHEY

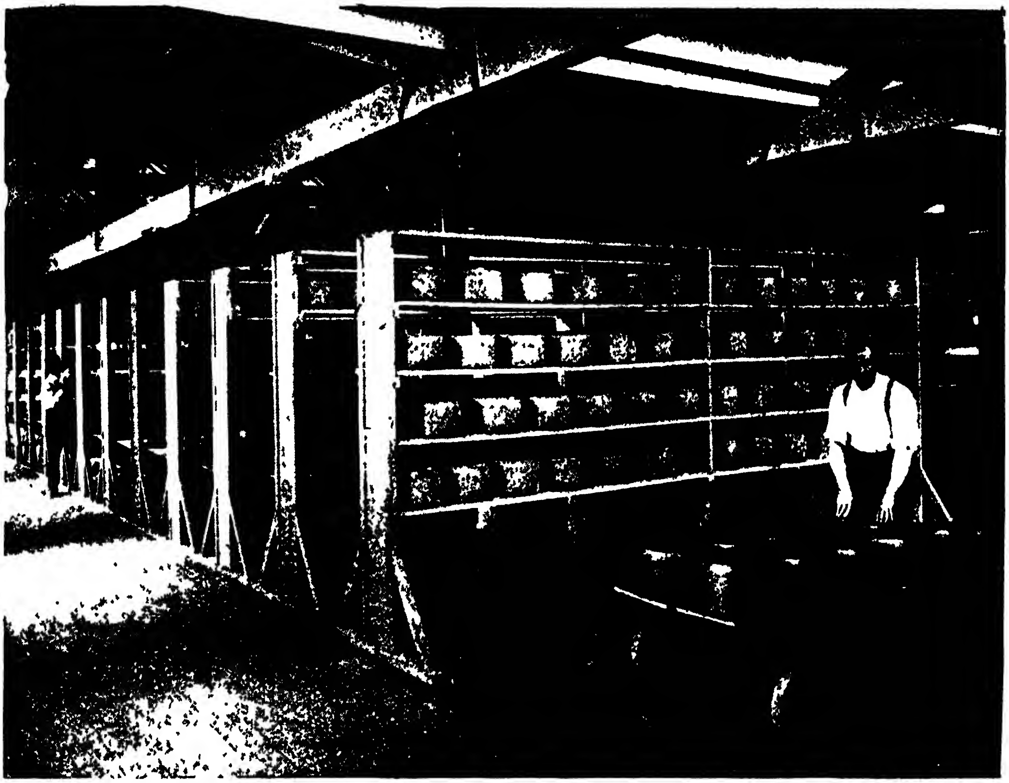
bowl of the quickly revolving separator, the cream collects in the centre, from which place it flows down through the cream outlet. Attached to the extreme outer edge of the bowl are one or more tubes that bend inward along the side, and form outlets for the heavy skimmed milk. So, as the milk enters the revolving bowl, it is divided into two portions the larger is drawn from the extreme outer part of the bowl, and consists of skimmed milk; the smaller portion escapes from the centre, and consists of cream.

When the cream has been separated from the curd and water, only the fat is taken from the milk. The removal of the fat does not in any way injure the other solids; they are still there, and still as useful for food. Separated milk is a wholesome and nutritious article of diet for the person of vigorous digestion who, for reasons of economy, desires to supply, in cheaper form than that of butter-cream, the fat required by his system. It provides the body with almost the same sort of nutriment that lean meat, eggs, and foods of a like nature do. Except that it is a very bulky form of nourishment for human beings, it is about three times as cheap as meat. It is a specially valuable food for calves and pigs. Hence its value in the Danish bacon industry.

Some butter factories, however, do not care to raise and cure pigs, and they have found a quicker method of using up their by-product. By evaporating the skim-milk, they obtain the curd or cheesy element; and out of this they make size that has various important uses. It is employed in sizing straw and felt hats; in making and glazing paper; for glazing and finishing leather, silk, and cotton goods, and for making linoleum. It is also an important ingredient of cements, glues, dry paints, and putty; and by a recent process it can be made into a hard, ivory-like substance, for handles, balls, buttons, and many other useful objects.

But while the skim-milk is being disposed of, the cream fat of the milk has to be ripened for the churn. That is to say, the lactic acid germs have to be allowed to work upon it; and on the way in which they carry out their part of the business depends the qualities of the future butter. The Danes leave nothing to chance. For they boil the milk before passing it through the separator, and so obtain a germ-free

PRESSING CHEESES IN AN AUSTRALIAN CHEESE FACTORY, VICTORIA



THE RIPENING ROOM IN A CHEESE FACTORY, WHERE THE FRIENDLY BACTERIA WORK UNSEEN

butter-cream. Then they introduce the lactic germs, by means of a starter made from a pure culture of the helpful little microbes. In this way they are able to control exactly the degree of fermentation in the cream. So their butter is admirably standardised in quality. The expense of first sterilising the milk and then cultivating pure cultures of the lactic germs is more than repaid by the fine, unvarying standard of manufacture thus maintained.

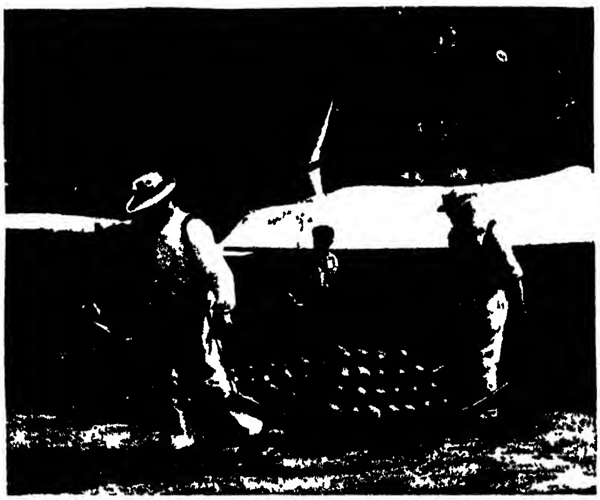
In the old-fashioned way the milk slightly ferments before it is cooled, and the fermentation goes on in the separated cream. It is hastened by a starter derived from the butter-milk a day or two before. This is a cheap and easy method. It is, in fact, the traditional method employed by butter-makers long before science revealed the reasons for it. But the germs that occur naturally in the starter of butter-milk are not under control. They may get mixed with other microbes, or they may become too strong or too weak. This is one of the chief reasons why old-fashioned butter-makers occasionally have curious troubles with their material.

When the cream has been ripened, it is necessary to get the minute globules of butter-fat to cohere together. This is done by shaking the cream until yellow grains of butter can be seen amid the butter-milk. In modern butter factories, great churns, revolving by steam power, are employed to consolidate the tiny globules. Sometimes the churn contains paddles, but these stirring instruments injure the grain of the butter particles. The best churns are entirely hollow vessels, shaped like a barrel or box, which throw about the cream that is in them until the particles of butter-fat unite in visible masses. As soon as the butter-milk is clear and watery, the churn is stopped, leaving the butter granules about the size of grains of wheat. The butter-milk is then drawn off from the bottom of the churn, and the butter allowed to drain thoroughly. It is then taken out, and worked into a solid mass, and salted and packed for the market. By means of refrigerating cars and marine cold storage, it can now be sent in a fresh condition for thousands of miles. This is one of the reasons why the vast modern butter factories have become so important and increasing a factor in this branch of dairy industry.

The factory system is also employed on a large and growing scale in cheese-making.

Here, again, the new and scientific manner of controlling the fermenting germs has revolutionised the process of manufacture. There is a story that an old-fashioned English cheese-maker, with a great contempt for the new-fangled scientific methods, managed to produce a cheese of exceptionally fine flavour. It had, besides, a distinctive quality that no other maker could imitate. The business of making this wonderful cheese so increased that the cheese-maker had to rebuild or enlarge his premises. Unfortunately for him, he resolved to have a new building. It was spotlessly clean and airy, and, to all seeming, a great advance upon the old small place. But when the process of cheese-making was begun in it the event was disastrous.

For though the old methods were used, and everything conducted with the greatest care, the cheese was commonplace in quality. All the distinctive flavour and character were lacking. The special kind of lactic germs acting on the cheese of the old house had not been imported into the bright, clean, curing-rooms of the new building. The old-fashioned cheese-maker was less wise than some famous French manufacturers—peasants for the most part—who know nothing about lactic germs, but always rub with some old matured cheese the shelves on which they set their new cheese to mature. This ancient practice is an excellent example of the most modern scientific methods.



UNLOADING DUTCH CHEESES FROM CANAL-BOATS AT ALKMAAR CHEESE MARKET, HOLLAND

As cheese contains the curd as well as the fat of milk, it is far more nutritious than butter. For those who can digest it, it is indeed an admirable food. When the organic minerals of the milk are preserved in the cheese, the result is perfect. Good cheese contains about 66 per cent. of flesh and bone forming elements and fat, and if well digested it possesses two to three times the food value of meat. It is most digestible when cooked with macaroni or vegetables. Usually it is made by pouring milk into a vat, and either souring the milk or curdling it with rennet. The curdling method is that chiefly used. The rennet is derived from the digestive stomach of a young calf. It is an active principle contained in the folds of the lining membrane, and is usually extracted by a commercial process, and sold to cheese-makers. It has the property of changing the curd of milk into a gelatinous mass in which the globules of cream fat are enclosed.

The rennet is a ferment that acts by contact; it is not changed by the changes it produces, and a minute quantity of it acts upon a large amount of milk. The riper the milk is, the quicker the rennet acts upon it. In other words, the lactic acid germs first sour the milk, and then the rennet forms it into a mass of wheycurd. There are about $7\frac{1}{2}$ parts of solid matter in 100 parts of coagulated milk, and the chief task of the cheese-maker is to separate the solid part from the liquid whey. In the factory process of Cheddar-making, the curd is cut in the vat by means of knives worked lengthways and crossways. The whey then begins to escape, and the cut curd sinks to the bottom of the vat, where it is kept in a state of gentle agitation that shrinks and hardens it. The curd is then heated, one of the results of the heat being to increase the activity of the lactic germs that the curd contains, and make them produce more lactic acid.

The whey is next emptied from the vat, and the curd is allowed to mat together into a mass, after which it is cut into blocks and drained. All this is done in a warm temperature, and the lactic germs multiply and act on the curd, changing it into a smooth, elastic, fibrous stuff, somewhat resembling in appearance the look of well-cooked, lean meat. It is ground in a curd-mill, and salted, and pressed into its final shape. It is then a green cheese, and it is matured by standing in pure,

warm air for some time. The lactic acid germs begin the fermentation, but they quickly disappear, and a new and still rather obscure fermenting agent then breaks the curd down, and imparts to the cheese its characteristic flavours. It takes from four to six weeks to make the cheese digestible, and it will go on improving for three to four months. It must then, however, be removed to a cool store-room, in which it may be kept for one or two years. Such, in outline, is the factory system of cheese-making by means of which the Canadians have captured so large a part of our Cheddar cheese trade.

Stilton differs from Cheddar in being made from sweet instead of sour milk; and no doubt a different kind of fermenting germ produces its characteristic flavour. There is, especially, a blue mould that flourishes in a Stilton curing-room, and works its way right through the cheese. Cheshire cheese is made from sour milk, but the lactic acid germs are not allowed to act so long on the curd in the vat. Moreover, a slightly colder temperature is employed in the maturing process, so that a different ferment is probably encouraged in the cheese. The soft cheeses, like Camembert, are obtained by allowing a considerable quantity of the liquid whey to remain in the curd. The renneting is done at a low temperature, and a part of the mould from the old cheese is often added to the milk. Roughly speaking, the lactic acid germs are chiefly instrumental in ripening hard cheeses, while the characteristic flavours of the softer varieties are produced by moulds and miscellaneous germs. It must be understood that the germs in a well-made cheese are, at the worst, harmless, and, at the best, assistants in digestion. As is now well known, a lactic germ is said by Professor Metchnikoff to prevent the poisoning of the stomach by harmful microbes, so that the milk foods prepared by means of it conduce to very long life.

A BUTTER FACTORY IN NEW SOUTH WALES

NATURAL WEALTH IN PRIMITIVE TIMES

IN EARLY DAYS MAN FOUND HIS WEALTH IN THE KINDLY FRUITS OF THE EARTH, AS SHOWN IN HUMBERT'S PICTURE FROM THE WALLS OF THE PANTHÉON

THE SOURCES OF WEALTH

The Necessary Parts Played by Land, Capital, and Labour in the Production of Wealth

THE INADEQUACY OF OUR SAVINGS

The requisites of wealth-production are, broadly, land, capital, and labour. More broadly still, they might be defined as land and labour. It is convenient to describe by the term "land" every natural agent that is to say, not only the soil of a given area, but every gift of Nature utilised by man, whether on, in, or under the land or sea. It is well to bear clearly in mind that labour is not, as is sometimes loosely said, the only source of wealth. Labour has to be exercised upon the world's natural resources; and those resources are so unevenly distributed as between one country and another, and as between one locality and another, that labour exerted at one place may be very ineffective in wealth-production as compared with labour exerted at another place. It may help clarity of definition if we express our meaning, in other words, by defining "land" as that which owes nothing to labour.

So far as the surface of the earth is concerned, great parts of it have been worked over in minute detail for long periods of time, in some cases for periods stretching back beyond the confines of human history. Year by year, an increasing part of the earth's surface is being brought within the scope of man's civilisation. There is perhaps no more wonderful thought connected with an old and developed country like the United Kingdom than the reflection that almost every acre of it has been in some way scraped, or pared, or cultivated, or mined, or drained, or built upon. Here and there one may find a small spot which has remained undisturbed for a generation or more, but even that has probably been subjected to cultivation or alteration at some not very remote period.

Land is the source of all our materials, and of all our food. To the agriculturist it is, of course, the prime material. To the industrial captain, it is a fixed base upon which to do certain work, and, in its broader sense, the source of raw materials. To everyone, whatever his calling, it means so much space upon which not only to work but to live. If we inquire what is the distinguishing attribute of land, we find it in the element of area. A certain piece of land is a definite space of the world's surface, the position of which cannot be changed in relation to other pieces of land. We see that this property is unalterable, and that it inherently attaches to land. Whatever else man may do to land, he cannot affect that distinguishing property. The fertility of land may be increased or decreased. The amount of work to be done upon a certain piece of land may be increased by erecting a building of many floors, multiplying the working space available in respect of it. A definite piece of land, again, may be mined, and minerals brought up for utilisation from far below the surface. A swamp or lake may be drained, and what was water-surface converted into more useful land-surface. These and many other things can be done by way of changing the character of land and the use of land. Through them all, however, it will be seen upon consideration, the unalterable quality of area, or situation, or extension remains.

It is of great importance to recognise this fact in relation to the wealth or well-being of a nation. The peculiar characteristics of land make it of primary importance in a nation's economy, whatever the condition of its development.

In an agricultural country, of course, the land is not only the living-place but the workplace of the entire community. We have seen in former chapters that with the progress of science it becomes possible to produce the food for many people

by the labour of a few. That means the constant and increasing transition of labour from agricultural to industrial pursuits; and for such labourers as are thus translated the land ceases to be a workplace, save in the sense that upon a certain area a man exercises some industrial art. In this respect, land plays a comparatively small part; even a large factory needs but a very small area of land for the conduct of its operations. Several hundreds of men can work upon a large plant erected upon the several floors of a factory which may not occupy more than a quarter of an acre. All the factories of the United Kingdom, if gathered together into one place, would occupy an insignificant part of the national area. Although this is the case, however, land does not cease to be important to those engaged in industry. The growth of industry means the growth of towns; and the Industrial Revolution with which the nineteenth century was mainly occupied in this country crowded some eight-tenths of the entire British population into urban areas.

Our Slow Loss of the Habit of Huddling Together in Towns

In the towns which have resulted from the Industrial Revolution, we witness a great disregard of the proper use of land in relation to industrial life. Whatever the work in which man is engaged, he needs, if not land upon which to grow food, at least space upon which to live in health, and upon which he and his family may exercise and disport themselves. To the urban dweller, the inherent and indestructible quality of land—space—becomes of added importance.

Time was when a number of causes restricted the size of towns. The first of these was the need for mutual protection, and the second was the limitation of the means of locomotion. Both these causes have become obsolete. Men no longer have to huddle together for safety within the walls of a narrow and defensible city. Men no longer need to limit the size of their towns by such locomotion as could be accomplished within reasonable time on foot or on horseback. This second truth is as yet imperfectly realised. We are slow to avail ourselves of the extraordinary facilities which the engineer has placed at our disposal.

We have now the means to arrange our towns in wide areas, with a wealth of those gardens and open spaces without which it is impossible for human beings to retain their health and vigour. It is now easily possible for a nation to turn its towns into sanatoria, combining every natural gift and amenity associated with rural life, with all those qualities of near association and communal life which are the essential attractions of a town. Town manufacturing and maintenance in all its branches is really the main industry of such a nation as ours. It is a great pity that this is not realised, and that we do not elevate it to a supreme art. If we did so, and if we concentrated upon it the best of our intelligence, we should so greatly add to national well-being as to transform society.

The British Improved Farm a Highly Manufactured Article

It will be perceived that as time passes, and as land is worked upon by the hand of man, the gifts of Nature as expressed in land become commingled more or less inextricably with the results of labour. This is true of both rural and urban land. A farm is not merely a piece of land; it is a manufactured article, and if it is a good and efficient farm it is a very highly manufactured article. We refer, of course, to the farms of an old country, and not to the lightly cultivated Bonanza fields of the New World, which are not so much farmed as scratched. In some cases a farm exists where once was a mere swamp, or where impenetrable forests were situate. A fen farm in Lincolnshire is the result of reclamation of area which at one time had none of the qualities of cultivable land. When we turn to urban land, we are again confronted with what is a manufactured article. The cost of making urban roads and pavements, and of furnishing them with proper sewers, water-pipes, and so forth, is exceedingly heavy, varying, of course, with the size of the plots which are reserved for human habitation. Even if houses are built only four or six to the acre, the cost of manufacturing the appropriate roads, pavings, sewers, etc., amounts to several hundreds of pounds per acre.

The Difficulty in Dividing Rent between Natural Gifts and Interest on Capital

Thus, what is commonly called the "rent" of either rural or urban land includes not only the *rent in its strictly economic sense of payment for natural gifts in fertility or situation, but interest on the capital which has been sunk in making or maintaining the farm* or urban land. Rent in its ordinarily used sense is not true rent as the economist defines it; and in practice it is very difficult to distinguish true rent from what is ordinarily called "rent." In relation to an ordinary farm,

for example, how difficult it is to decide what part of the annual sum paid for its use is paid for its natural qualities and situation, and what part for the artificial things—the buildings, hedges, ditches, etc.—which make it a farm! It is easier to distinguish true rent in the case of an urban site, for there we are able to estimate closely what the building or other improvement is worth, and therefore to value the essential and distinguishing situation for which an annual sum is paid, which is truly "rent."

The Natural Rise in the Value of Land Because of its Limited Amount

Land is obviously limited in extent. The land area of the world amounts to only about one-fourth of the entire area of our not very large world. The United Kingdom has an area of only 77,000,000 acres. Land is thus a commodity which can be very easily monopolised. As the population of a country grows, the land remains the same in area. Every addition to the population, other things remaining the same, raises the degree of use to which the land of a country is put, and therefore increases its value. Consequently, in a growing country, the value of land and the rent of land must grow, and the owners of land must be able to secure an increased income from it. Great political and social problems thus naturally arise in connection with the forms of its ownership or tenure: and in all the countries of the world these problems are being worked out with very great difficulty and in many different ways.

We pass from land—from the gifts of Nature—to the labour which, intelligently exerted upon natural gifts, produces material wealth. We picture man in his primitive condition ruling over what were practically unlimited quantities of land, and, by the aid of a few very simple arts, wringing from great natural wealth a bare subsistence.

Natural Wealth Only Yields its Stores to Intelligent Labour

We are reminded here that, just as it is true that labour alone is not the source of wealth, so it is true that a great and bountiful natural store of wealth may be used but little, and yield a scarcity of material wealth to unintelligent labour. Time was when the extraordinarily wealthy area we now call the United States of America was the happy hunting-ground of peoples who knew not how to employ the natural abundance which encompassed them. We must recognise that they obtained freely the means of physical health and development, but they were only able to do this because their numbers were few. Land was to them unlimited, and the chase, combined with rude forms of cultivation, yielded them in ordinary times a sufficiency of food. Even in such a primitive form of life, however, we see the beginnings of those *storings of the fruit of labour which we call capital.* The Indian who spent a day, or days, in fashioning a weapon with which to hunt was engaged in storing labour for the purpose of securing more wealth with less labour. Every hour's work spent or stored in fashioning a weapon or an implement meant the saving of many subsequent hours in the pursuit of wealth.

Presently, as man progressed in civilisation, he began to domesticate certain animals, and flocks and herds became the chief expression of the wealth of families or tribes. As cultivation became better understood, cultivated land became an expression of saved or stored labour. In cold countries man had, from the earliest days, to spend and store labour in the form of rude clothing, and of huts or other habitations. So gradually there grew, from age to age, the stores of wealth of material things which are an expression of the intelligence of men in spending the labour of the present to provide for the known and anticipated needs of the future.

The Growth of Stored Labour, or Capital, Through the Power of Machinery

In modern times, beginning, as we have seen, with the middle of the eighteenth century, capital or *stored labour* began to assume a new and gradually increasing importance. The age of mechanical power began, and in 1912 that age is still young. We have come to learn that by spending a considerable amount of labour upon the construction of machines we can, with the aid of those machines, multiply human effort a hundred-fold or a thousand-fold, and, in effect, turn the labour of 45,000,000 of people into the effect of the labour of hundreds of millions, or even thousands of millions, of people. Perhaps we ought not to say "we have learned," for it is exceedingly doubtful whether this truth is realised in all its fulness by more than a fraction of our people, and most certainly the powers that we possess are not fully exercised.

The progress of science and machine-production have elevated capital into an entire supremacy over land as a factor of production. Before the industrial era, land and labour and a very little capital sufficed for the operations of mankind. Today, large amounts of capital are necessary for the conduct of every business. Even the

farmer who takes up, *without payment or rent*, a quarter-section (160 acres) on the Western prairie—the natural fertility of which is so great as to yield abundant crops for many years without manuring—needs several hundreds of pounds' worth of capital to equip himself with the necessary appliances. As for industry, what a contrast obtains between, say, the old textile operations, with their simple spinning-wheels and hand-looms, and the modern textile mill, with its intricate and costly machinery! Textile operatives are still cheaply housed, but each unit works with a plant of great value. Probably, in a modern cotton-mill, the amount of capital employed for each operative amounts to hundreds of pounds. Or take our railways at the value at which we put them in the last chapter—viz., £1,215,000,000. The number of railway-workers, men and boys, is about 800,000, so that for each employee of British railway companies there is about £1500 worth of capital. A good deal of this capital has been "watered," of course, but, even allowing for that, we see how large a part capital plays in relation to the persons employed.

Essentially we see that the store or stock which we call capital consists of putting by the fruits of labour in forms of some permanence; but, of course, real permanence does not attach to anything that man can store, save to a few of the metals. *The storing of capital means, therefore, not only the saving of it, but the preservation and guarding of it.* If the capital stock is saved in the form of a building, the building must be constantly repaired and protected from the effects of the atmosphere. If man takes his hand from the building which he has made, a process of deterioration immediately sets in. If the storage takes the form of a machine, the machine must be constantly cleaned and oiled, whether in use or not in use. If the store be grain, then expensive arrangements must be made for its preservation for even a limited period while many forms of food can only be stored for a very restricted period indeed This expenditure of labour upon maintaining capital is often overlooked. Consideration will show that it follows from it that when capital is lent by A to B, B has not only to pay A positive interest on the sum lent, but to maintain the capital lent, which is the equivalent of a sum which we may call negative interest. This may be clearly illustrated by the case of a man who possesses two houses, but who only desires to occupy one of them. If he desires to maintain the value of his second house, he must employ a competent caretaker to keep it clean and in good order, and that, of course, is a matter of considerable expense If, on the other hand, he lets the house, he gets, in addition to the rent which is paid, the care and cleaning of his house for nothing. It is obvious, therefore, that the real interest which he receives is not merely the sum which is agreed upon in the lease, but the value of the care and cleaning of the house, for, if he had no tenant, he would have to employ caretaker and cleaner.

A DISTRICT OF ENGLAND RECLAIMED BY A CANAL BUILT BY DUTCH IMMIGRANTS IN FENLAND

Thus it is with all capital. In the famous illustration which Bastiat employed to illustrate interest, he pictured a workman, possessing two planes, lending one of the planes to a second workman, and the second workman, in return, paying the first part of the extra produce which was the result of the employment of the plane Thus, Bastiat showed that although the second workman paid interest to the first, he really gained, because the use of the plane enabled him to do more work than would otherwise have been the case; after

paying interest for the plane, that is, the second workman was better off than if he had not paid interest. This, however, does not cover all the considerations involved, for it will be seen that the practice of interest involves not only the payment of part of the produce of the capital lent, but the preservation of the capital intact and undiminished (*i.e.*, the plane is assumed never to wear out). At least, that is what happens in some cases, and it is what the investor hopes for in every case. As a matter of fact, we know that very often capital lent is entirely dissipated in fruitless endeavour, and that the investor obtains neither interest nor the preservation of his capital.

It demands not only intelligence but self-denial to store the fruits of labour. Interest has been sometimes defined as a reward of abstinence. That, of course, it certainly was in the preliminary stages of capital accumulation, and that is how saving presents itself even today to the man of small and moderate means. It requires no little abstinence for the man with 30s. or £2 a week to put by any proportion of his earnings, however small. And the greater amount of saving today is done by persons who already have incomes large enough to command much more than the necessaries of life; and it is not very appropriate, therefore, to regard their further accumulations as "abstinence."

As to the quantity of capital employed, we gave reasons in the last chapter for believing that although the British accumulations are actually great, they are relatively small when the enormous size of our population is concerned. We need a larger capital than is at present employed, both as to the framework of social life and for the purposes of economic production. If, for example, we consider the grave and great matter of the private houses and public buildings of the community, with their necessary complement of developed connections in the shape of properly made roads and streets, with all their furnishings in connection with lighting, draining, etc., an enormous amount of capital is called for if forty-five millions of people are to be housed with due regard to the maintenance of perfect health, and if they are to enjoy such a standard of comfort as we should desire for every man after so many centuries of development, and in view of known and proved inventions. If we take 45,000,000 people to represent 9,000,000 families, and if we assume that to provide them with proper amenities costs no more than £1000 per family, apart from the value of any land used, then these things alone would, it will be seen, demand the use and maintenance of £9,000,000,000 of capital. If this is compared with the valuation of existing capital of the kind given in Chapter 25—and that valuation, be it remembered, included the land value —it will be realised how inadequate is the amount of capital yet applied to this the primary need of a civilised community. As a matter of fact, even £1000 does not go very far in providing town housing of first-

CLEANING OUT A FEN-CUT OR LARGE DRAINING CHANNEL ON THE RECLAIMED THORNEY ESTATE

class type, in which the best materials and workmanship are employed.

The fact is that our conceptions of what is possible, in connection with the economic use of capital, have not yet developed very far. The greater number of people come to look upon life as a thing which, in the mass, must necessarily be mean and sordid. The average conception, it is to be feared, is of a great mass of people living at a low scale of existence, in which a limited number of them may enjoy a considerable amount of comfort. Society is visualised as a body of individuals in which a certain proportion of them may, by luck or judgment, or both, rise out of the mass into a condition of superiority and decency.

It therefore rarely occurs to us that the known conveniences of comfortable life ought, by this time, to be widely used, and not merely used by a few people. To illustrate our meaning, take the matter of the heating of houses. We live in a climate which, while it has many virtues, yet bestows upon us some seven or eight months of wintry weather, during which houses are uncomfortable and unhealthy things if they are not properly heated and ventilated.

The Failure to Realise Advantages that Capital Might Easily Bring

And it happens that we live in a country which, as we saw in a preceding chapter, is one of the few great fuel-producing countries of the world. Therefore, an intelligent inhabitant of Mars might imagine there would be *no difficulty for the British people in keeping themselves warm* in their long winter. In practice, what happens? A very limited number—a ridiculously small proportion of the whole—of well-to-do houses are thoroughly well heated. For the rest, the less said in this respect the better. Even the houses of the middle class are very inefficiently warmed; and the larger number of middle-class people do not heat their bedrooms, but leave highly warmed sitting-rooms to go to sleeping-apartments in which they themselves are the only furnaces. It is not a little extraordinary that some millions of middle-class people, who ought to know how easily heating can be done, are content to warm their beds with their own bodies. As for the working classes, a large proportion of the workers maintain with difficulty *one fire in one room;* and the idea of warming a bedroom would be hailed with hilarity. Yet, of course, the application of but a moderate amount of capital in the building of houses could efficiently warm, at small outlay, the whole of every house. It could be done for the entire nine million houses of the country at an average expenditure of £70 per house. This would mean an enormous saving of the greatest national asset—coal—for it would be necessary, even on a system of separate dwellings and separate heating for each dwelling, to have but the burning of one fire for the purpose for each house. These practical problems of life will doubtless be settled long before the present century has run its course; and it will be apparent what a tremendous sphere for activity remains to be developed in connection with them, and what large opportunities for trade of at present unthought of dimensions will exist.

The Uneconomic Use of Wealth when it Falls Into the Hands of a Few

Great and profound are the effects of the distribution of wealth upon the accumulations of capital. As we have already seen the manner of spending money determines the occupations of the workers of a nation and when a very large proportion of the national income is possessed by a limited number of people we get an encouragement of the trades of luxury and a discouragement, *pro tanto*, of the trades of necessity. There is a corresponding influence thus exerted upon the use of capital. The demand for goods of a certain character naturally causes a flow of capital into the stimulated trade. If a man, receiving an enormous income, builds himself a second or third house for very occasional residence it is true that he employs labourers in building the house, and that he afterwards has to employ persons to clean and maintain his extra house, whether he is in residence or not. It is apparent, however, that the capital spent in building the extra house—say, £20,000—is unproductive, and the income which is used up in maintaining an enlarged retinue of servants to care for the house simply maintains so many persons in economic idleness.

The Spasmodic and Casual Use of the Country's Capital

If the £20,000 had been sunk in a productive business, in setting up a new factory, and establishing in it productive plant, just as much labour would have been commanded as before; but the factory, the thing called into existence by the sinking of the capital, would add its income of produce year by year to the wealth of the country, and would employ usefully as many persons as, or more persons than, would be employed wastefully in the rich man's additional house.

As things are, the country is supplied with capital for the various purposes of social life, trade, and industry as it were casually. There is no set purpose in saving; there is no specific national or social aim in accumulation. The thing resolves itself into a more or less spasmodic and chance investment by various individuals, who spend and invest upon no fixed principle, and whose sole object, of course, is individual gain. No one surveys the country as a whole, and forms an estimate of what capital stock is needed to render the labour of its people more productive. There is absolutely no means of organising capital-saving. It is very questionable whether this plan, or lack of plan, can for ever continue to be regarded as satisfactory by an intelligent and advanced people. The proper use of capital, of stored labour —of, in the words of John Stuart Mill, the "accumulated stock of the produce of labour"—is essential. If labour is to be economically exercised, it must be put forth in connection with the use of the best-known appliances that have been devised by the genius of man. Any labour which is not so applied is wasted in some degree.

The Inefficiency of Much of the Modern Use of Capital

If this test be applied to industry and trade as they are, how woefully we fall short of a proper standard! Whether it be manufacturing, or whether it be housing or retail shopkeeping, it must be confessed that it is only the minority of capital units which are thoroughly efficient, or which display knowledge of, or at least the use of, the best appliances that have been devised. It is the fact that, whether we take industries as diverse as the iron manufacture, or the woollen manufacture, or the building trade, or bootmaking, or jam-making, or printing, it is only the minority of firms engaged in them that could pass muster as being possessed of capital in its highest form for the purposes of its trade—viz., (1) a thoroughly well built and efficient factory or mill, (2) the latest and best machinery that has ever been invented for the purposes of its industry, (3) such provision for the comfort and welfare of the workers engaged as to secure from them the best output of human skill and labour.

It is probable that some day capital will be accumulated more methodically on behalf of the nation as a whole. If a nation had a mind to do it, it could put aside year by year, out of the national income, a stock large enough to regenerate not only the living-places of the country but the working-places of the country. That would amount to a pooling of interests, and it would therefore amount to an absence of risk for the individual. As things are, investment results from the risks of a certain number of private persons who, in the pursuit of gain, take their chances. In this process an enormous amount of capital is altogether lost. Shady financiers are always offering the bait of high interest, and they succeed in wasting enormous sums in spite of all the legislative attempts which have been made to protect the investor.

How a Casual Use of Capital Leads to Waste Through Over-Capitalisation

But it does not need actual dishonesty to secure the wasting of capital. Quite honest persons desirous of achieving a certain end are over and over again tempted to embark upon schemes with insufficient capital for their purpose. There is always an enormous wastage of capital going on, because of competition. The question whether there is enough capital in a trade can only be realised in such a community as ours by experiment of the most rough-and-ready description. A want arises, and a "boom" follows as it is realised that there is a chance to make money by a certain form of investment. Investors rush in to the new and attractive proposition, and company after company is formed to exploit their desire for gain. What was originally legitimate soon becomes highly speculative, and tens of millions are poured in before the boom collapses through undue capitalisation.

The Failure of Attempts to Trade by Methods of Casual Speculation

Some rough idea may be formed of what the individual *attempts* to save have been in the last fifty years or so. The record of the companies registered under the Companies Act, passed in 1862, covers a considerable part of the attempts to save capital which have been made since that date. Of course, not all saving goes into joint-stock companies, but the joint-stock principle has extended so widely that certainly at the present day the greater part of saving is exhibited in this form. The figures cover the capital not only of trading undertakings, but of banks, of privately owned gasworks, and of tramways, but they do not cover railways, which are not registered under the Companies Act.

We find that in the years 1862–1910, for which figures are available, 113,900 joint-stock companies have been registered, with a total nominal share capital of £7,300,000,000.

Now let us see what has been the fate of these companies and of this enormous mass of capital. The Registrar of Joint-Stock Companies gives us a table showing how many companies remained in existence in April, 1910, and the amount of their capital. We find that it is a little less than £2,200,000,000, and that the number of companies remaining in existence is 51,800. Thus, in a period of forty-eight years 62,900 concerns, or far more than half the companies registered, have actually disappeared into space; and whereas £7,300,000,000 of capital has been registered, only £2,200,000,000 remained in 1910—a nominal loss of £5,100,000,000. Let us set out these extraordinary figures to make them clear.

LOSS OF JOINT-STOCK COMPANIES, AND THEIR CAPITALS.

	Number	Nominal Capital
		£
Joint-stock companies registered in 1862–1910	113,900	7,300,000,000
Joint-stock companies believed to be still in existence and carrying on business in 1910	51,800	2,200,000,000
Companies and capital which have disappeared in 48 years	62,100	£5,100,000,000

Allowance should be made for the fact that the mere registration of capital does not necessarily mean the registration of new capital or of real capital. Sometimes the registration of a joint-stock concern merely amounts to the registration of old capital, not a new saving. Sometimes, again, it is the registration of mere "water." We cannot tell how much of the £7,300,000,000 meant the registration of real capital, and equally we do not know how much is genuine capital in the £2,200,000,000 of capital remaining registered. When allowance is made for these considerations, the facts adduced remain sufficiently remarkable. They point to an extraordinary wastage; they point to the *frustration of attempts to save.*

There must also be a very considerable amount of frustration of saving in connection with the capital matters which lie outside the company record; and it is only too plain that we have not only to contend with insufficient attempts to save, but with an enormous wastage of such attempts as are made.

Whether it will be possible to evolve a more efficient and serviceable supply of capital remains to be seen. We get the hint of what is possible in connection with railway enterprise and canal enterprise and afforestation and canal-making in many countries. The cutting of the Panama Canal by the United States of America is an instance on a large scale of the employment of capital by a nation. Will it ever be possible for nations to make their necessary savings as a whole, and to throw overboard the system of depending upon the caprice of individual investors and speculators?

Will it always be necessary to leave the making of homes to speculative builders, and the erection of factories to speculative capitalists? The problems involved are difficult in the extreme, and it is not possible to dogmatise as to what developments may possibly be. In the beginning of the twentieth century these problems are exercising the best minds in all the great nations; and the modern economist is no longer content to base his theorising upon the conception of individual petty trading. With a wider horizon, he opens his mind to the consideration of all the possibilities; and the larger scale upon which industries and trades are now conducted makes him cautious in rejecting large-scale solutions.

Thus we find Professor Taussig, who occupies the Chair of Economics at Harvard University, frankly contemplating the possibility of the accumulation of capital by a great community collectively. He points out that it would simply proceed by a different process from that which we now know of; not by the savings and investments of individuals, but by the community deliberately setting aside part of its annual income of resources for new construction. The "abstinence" would not be that of a few, but of the community as a whole; and this means, of course, that, as the risk would be pooled, individuals would not feel any deprivation or undergo any risk. It is true that each individual would, as a member of the community, go without a proportion of annual income that he would otherwise have, but he would not be aware of the fact unless he were told of it, and he would not

as is now the case, be haunted by the fear of losing an "investment" and being brought to loss or even ruin.

A glance may be usefully taken at the record of company capitals registered in recent years. Here are the figures.

NEW JOINT-STOCK CAPITALS REGISTERED IN THE UNITED KINGDOM

Year	No. of Companies	Total Nominal Share Capitals
		£
1896	4,735	309,000,000
1898	5,182	272,000,000
1900	4,966	222,000,000
1902	3,929	157,000,000
1904	3,831	93,000,000
1906	4,840	137,000,000
1908	5,024	104,000,000
1910	7,184	213,000,000

These figures cannot be regarded as exhibiting a sufficient degree of accumulation.

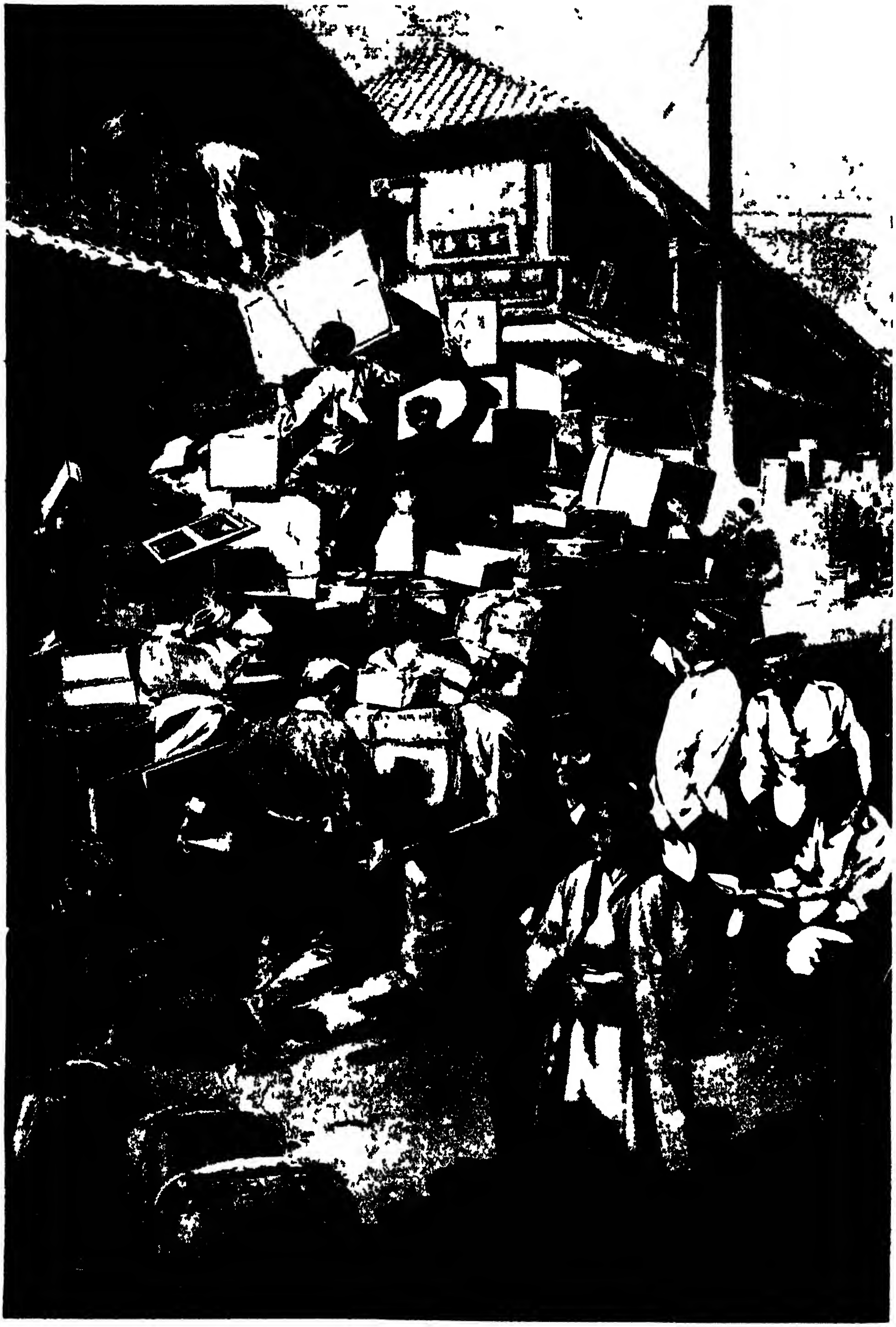
One of the most difficult considerations in connection with the capital savings of a nation is to decide what proportion of its savings can be properly devoted to investments outside its borders. We can see at once that if the old civilisations of the world refused to devote any part of their savings to the development of new countries, it would be bad not only for the new countries but for the old ones. The development of places like Canada and Australia and Argentina means a great addition to the wealth and comfort of places like the United Kingdom and France and Germany. Britain gains enormously from the command and use of foods and materials which can be plentifully raised by the employment of capital in the New World. It would be absurd, therefore, to say that foreign investment, *per se*, is bad for a nation. On the other hand, it is equally true that a nation cannot afford to see the whole or the greater part of the investments of its citizens made abroad. The ideal position is for the home country to be saving enough to develop itself, and to employ thoroughly well the labour within its borders, while supplying a surplus of capital to the development of other parts of the world.

In recent years the amount of investment in places oversea made by British investors has undoubtedly been very great; and the evidence seems clear that it has been larger than the amount of investment of British capital at home. Whether or not the balance has been well kept it is very difficult to say, but there is at least some fear that the vogue of foreign investment has become too great. The explanation of so much oversea investing is very simple. New countries are able to offer the bait of a high rate of interest, and the increasing confidence of investors in the stability of conditions in new countries has greatly increased of late. Of course, as new countries increase in stability and importance, they will be able to obtain capital on better terms, and the supply of native capital will increase. Consequently, there will be a better equilibrium of conditions after a certain interval of time. In the meantime the subject demands from public-minded men a much more careful study than has yet been given to it.

In one direction it is probable that not nearly enough capital is yet risked, and that is in experimental work and research. It is naturally not a little difficult to get individual investors to risk their money in paths which, although speculative, ought to be pursued for the general good of the public. When thousands or tens of thousands of pounds are needed to pursue a certain line of inquiry, they are often not obtainable because of the difficulty of individual risk. Here, at least, is a direction in which it is necessary for modern Governments to employ capital. It would pay to lavish money upon experimental work and to encourage invention by every possible means of stimulation.

In spite of our preliminary economic definitions, for the practical purposes of trade and industry we may regard land as capital. We may do this because nearly all land has been appropriated, and, because of individual private ownership, is to be bought and sold like any other commodity. The distinction between land or natural agents, and capital or stored products of labour, does not exist in the practical world of trade. The industrial captain, embarking upon a new business venture, goes into the market and buys or hires land, purchases plant, and hires labour. To him the main problems are to command sufficient capital and to produce at as low a cost as possible. In the endeavour to produce cheaply, it is his aim to employ labour economically. We shall next proceed to examine the methods by which labour is exercised to the best advantage, and consider the effect of those methods not only upon industry and trade but upon society.

SANITARY PURITY BY ORDER IN JAPAN



On the approach of the plague the authorities in Japan demand systematic "spring cleaning" in all houses and supervise the operations, turning out the furniture that the work may be done thoroughly.

SOCIETY AND DISEASE

The Growth of Public Care for the Health of All for the Sake of All

WILL STATE TREATMENT BE UNIVERSAL?

With a single exception, in the far-off past, intelligent, organised public care for the health of all, for the sake of all, had made scarcely any headway till sixty years ago, and could not be said to be accepted and well established till thirty years ago. The relations of Society to Disease have only been defined in this country since Victoria came to the throne, though England cannot be regarded as comparatively backward in sanitation.

At first sight one might think it strange that a question so universal and so important should not have been grappled with sooner, and that effective sanitation leaps the ages from the days when the Jews were a nation to the middle of the nineteenth century. But we must remember that medical and sanitary knowledge is a recent growth. Harvey's essay on the circulation of the blood was not published till 1628. The mechanics of the air, on which ventilation is based, were only understood scientifically in the eighteenth century. Even in the middle of the nineteenth century the simplest principles of health were regarded widely as fads; and today the popular idea of medicine remains largely a gross superstition, as is proved by the financial success of quackery.

The idea of the public preservation of health, which is now flooding in amain, spreads quite as quickly as the world is ready to receive it. The attempt of Society as a whole to deal with disease as a whole is one of the stupendously beneficial changes that have come with the successful study of natural laws, in times within the memory of our fathers. Such an attempt could not have succeeded earlier, for the state of knowledge would not have warranted it. Its future, as we hope to show, is fascinating.

Of the state of early man in relation to disease we have no evidence, except that he had no idea of sanitation. What his diseases were, and his immunities, no one can say. For the most dread diseases come and disappear, according to invitation or repulsion by hygienic conditions—black death, sweating sickness, plague, cholera, typhus, ague. Primitive man may have had troubles not ours, and immunities not ours. It is strange if he did not suffer, for he left the remnants of his food festering about him in mounds of refuse. Very early considerable protection would be given to water by religious sentiment. Christianity inherits its holy wells from the people of the Stone Age, as anyone may gather from a tour in Brittany.

The Hebrews were the people of antiquity who seem to have been most successful in framing hygienic rules. Long life was a reward of their religion, and they sought it by the wisdom of cleanliness. The result has been that, notwithstanding many adverse circumstances, the Jews have remained through the ages—no doubt owing to an inheritance of hygienic traditions—a specially healthy race. It is curious how the old and the new meet, for the modern gospel of health may be summed up most succinctly as a gospel of cleanliness—in person, house, street, air, water, and food.

We know that the towns of antiquity—Nineveh, Athens, Rome—had systems of sewers. These were needed to carry off the storm-waters, and no doubt acted as scavengers incidentally. The Greeks, with all their love of physical beauty, never organised a communal health system, unless Spartan rigours could be brought under that head. Rome stands out conspicuously in the story of early hygiene because of its appreciation of water. The bath was an institution round which centred much social life, and its hold on the people is shown

by its spread throughout the Roman world. The Roman established his bath everywhere as the Englishman establishes his sports; and his bath and road defy time.

The water service of the dominant city, public and private, was magnificent, and involved sewers and a certain amount of sanitary cleansing. It is said that Rome had a main sewer down which a cart of hay could be driven, and her abundant water enabled her to use the modern flush for her refuse. Her health regulations are illustrated by the fact that no body could be buried within the city—a rule that gave rise to the catacombs. Rome also had a kind of public medical service, and laws of nuisance as between person and person; so that, though medical knowledge was slender, the organising Roman mind evidently grasped some of the main elements of public health. That the public adopted hygienic conditions may well be doubted, for we know they could not be weaned from a taste for the waters of the Tiber. After the fall of Rome followed a thousand years of filth, disease, poverty, and misery.

The Set-Back to Sanitary Conditions Through a False Contempt for the Body

In revolt from Roman luxury and pleasure the Christian Church set up a rule of self-denial, abstinence, and rigorous suspicion of the claims of the body. The mortification of the flesh was a sign of piety, and noisomeness an accompaniment of holiness. What wonder if disease rioted through city and hamlet? Plague after plague, started in filth, and finding a seed-bed everywhere in filth, swept over the world. Leprosy was spread from the East by the Crusades, and disease and poverty sank the nations in despair. The only organised attempts made to stem the onflow of disease were the segregation of the leprous and the establishment of quarantine against plague—a restriction that often was quite useless, because it was not understood how plague is carried. The need for dealing with leprosy and with deadly epidemics was so patent that it forced even the mediæval world into communal action, but epidemics were regarded as extraordinary conditions, though they recurred incessantly, and it took centuries of experience to find any need for everyday hygiene.

The monastic institutions had been compelled to recognise at an early date the close association between poverty and disease, and they built and maintained, for the sick, hospitals which, in later years, often became the foundations of the great modern hospitals under medical supervision. It is a curious fact that, early and late, from the Tudors to the present time, it has been the enforced care of the very poor that has led the way to care by Society for the health of its members generally, irrespective of wealth and poverty.

The Philanthropic Attempts to Help the Poor in Tudor Times

The Tudors made many attempts to organise relief of poverty and sickness. It became incumbent on them through the suppression of the religious houses, which heretofore had cared, more or less, for him that had no helper. They laid down conditions for medical practice, established commissions of sewers, built pesthouses to which infected people must go at the expense of the rates, and originated Overseers of the Poor, who could apprentice children, with power to call upon the rates. They called upon the local authorities and on private philanthropy to do all that was possible for the genuinely sick and destitute, and hospitals were established or reinstated to help. Thus St. Thomas's dates from 1553, St. Bartholomew's from 1546, and Bedlam from 1547. At the same time the most cruel penalties were enacted to punish "vagabonds" who traded on charity. For the first offence the purloiner of the charity meant for the "true poor" could be whipped, for the second branded, and for the third offence hanged.

But all this was of small avail towards keeping the health of the people good, for the ground in the towns was saturated with the filth of ages, and the cesspools of the best houses were under the houses themselves, and no one knew either how to cleanse away the public offences or the exact manner in which those offences took toll of human life. When the Moor-ditch and Fleet-ditch swept their abominations into the Thames, the effect was to befoul its banks afresh; and from the hygienic point of view the purifying Great Fire of London came as a crowning mercy.

The Helplessness of the Eighteenth Century in the Face of Disease

The Eighteenth Century was a time of active preparation in the minds of advanced men for the great strides taken by State medicine in the Nineteenth Century, though neither science, nor law, nor public opinion was yet in a state to take or accept any efficient control of society on behalf of the general health. There were no

funds to undertake any sanitary work; no legal powers of restriction, except when an epidemic was imminent; no registers of compulsorily notified births and deaths to show the consequences of neglect, and no clear ideas by scientific men as to what should be done.

Great Medical Advances of the Eighteenth Century Without Public Organisation

Yet it was a century of considerable advance, though its generations were decimated by small-pox, typhus, and scurvy, and racked by ague. The determination to relieve the terrible physical sufferings of mankind grew strong under the noble influence of men like John Howard, one of mankind's truest, if least sensational, heroes. The idea of preventive medicine was diligently spread by men whose names ought never to be allowed to pass into forgetfulness—by Dr. Richard Mead, who wrote, in 1720, on Methods to Prevent Pestilential Contagion, and contended that all expense should be paid by the public, and no cost could be too great if prevention were secured; by Sir John Pringle, who discussed (1752) "the right management of air," particularly in Army hospitals; by Dr. James Lind, who wrote of scurvy and infection in the Navy; by Sir Gilbert Blane, who gave lemon-juice to the Navy; by Captain Cook, who showed, in practice, how voyaging might be kept healthy; by Sir George Baker, who revealed how lead-poisoning came through cider; and by Edward Jenner, the discoverer of vaccination. These investigators enunciated the principles of public hygiene that have swept out of existence the principal diseases which scourged the men of their own generation.

The Cost of the Workhouse Sick as the Real Cause of Public Sanitary Reform

When, in 1830, William the Fourth became King, Society had taken no step to grapple with any form of disease in its midst, except that there was a Quarantine Act and a National Vaccine Board. The Commissioners of Sewers were engaged not in disposing of sewage, but in keeping the country dry, by getting rid of flood-waters. Then, Asiatic cholera forced the pace by sweeping down on us, and slaying 50,000 people in the United Kingdom. This appalling visitation caused, in 1831, the formation of a provisional Central Board of Health to give advice, but to exercise no control. A new Poor Law Board was also formed, with Mr. Edwin Chadwick (afterwards Sir Edwin), the inspirer of the modern health movement, as its Secretary; and in 1837 the Act for registering Births, Deaths, and Marriages was passed.

This was the state of the case when Queen Victoria began to reign. There were practically no health laws, no powers of compulsion, no official organisations for scientifically securing local or general health, and no clear ideas of what was needed, and how it could be brought about. Care for the public health has taken official shape entirely since then.

The real initiation of Sanitary Reform came by way of the workhouse. To the workhouse went the multitude stricken both by poverty and disease, and the public was bound to keep them. Besides, disease brought premature age or permanent infirmity. The country groaned under the financial burden, in concert with the racked populace groaning under its sufferings. And, naturally, to those who saw, close at hand, what was happening, the thought occurred: Would it not be cheaper, at almost any price, to prevent this expensive ravage by disease?

The Enthusiastic Inspirer of the Public Health Movement

That is the central thought of all hygienic science—it *is* cheaper in money, in life, in enjoyment, in industrial efficency, and indeed in every way, to grow people well from youth, and to keep them well, than to cure them, or nurse and preserve them, by any conceivable methods. And in the proportion that everybody is kept well, everybody is kept out of danger from contagion or infection. On that principle, the administration of Public Health has been proceeding for between sixty and seventy years, with a constantly accelerated pace, and is likely to proceed until we have a healthy nation. Before discussing problems of the present and future, we wish to trace further the course of the practical progress already made.

Edwin Chadwick, a friend of Jeremy Bentham, the philosophic publicist, became in 1832 an Assistant Commissioner inquiring into the working of the Poor Laws, and in 1833 was made one of the Commissioners of the Inquiry, and also a Royal Commissioner examining the treatment of children in factories. The report of the Poor Law Commission in 1834 led to the passing of an Act which created a permanent central administrative commission, and Chadwick was made secretary, and in that capacity he initiated the public health movement.

On the ground that "all epidemics and

all infectious diseases are attended with charges, immediate and ultimate, on the poor-rates," the Commissioners made an inquiry into sickness and destitution, and were assisted by three doctors—Arnott, Southwood Smith, and Kay. The report of these doctors was terrible reading. For example, of 77,000 paupers under review in a single year, 14,000 were attacked with fever. Indeed, the country reeked with fever poisons.

The Advent of Possible Public Health Through Permissive Legislation

The House of Commons then took up the matter, and appointed a committee. The general report of the Poor Law Commissioners was written by Mr. Chadwick. It pointed out that the natural probabilities of life in England were thirteen years below the probabilities of life in Sweden. It recommended universal drainage, the removal of refuse by water carriage, and the improvement of water supplies.

A Royal Commission was now appointed, with Mr. Chadwick in consultation as adviser. It confirmed the Poor Law report and recommendations, and a temporary Act for the Removal of Nuisances and Prevention of Epidemic Diseases followed, in 1846; but it was not till 1848 that a Public Health Act was passed—the basis of all modern legislation of a like kind—establishing a central General Board of Health, giving summary jurisdiction in case of offences complained of by a local authority, and allowing financial powers to find the wherewithal for local sanitary improvements and regulations.

Here then, at last, organisation, law, and money were all brought into operation in the cause of health. The Act was to remain in force for five years. Its defects were that it was permissive only, and it made no arrangements for meeting the cases of local authorities that were disinclined to move.

The Fate of an Indiscreet Reformer who was Before His Time

The General Board of Health had a stormy career. Mr. Chadwick, its secretary, was an enthusiast, a "hustler," as we should now say, and a believer in centralisation. The local authorities generally were not enthusiastic, would not be bustled, and resented interference. Chadwick, unfortunately, had not the qualities that lead to the smoothing over of difficulties. The result was that at the end of the first term of the Board's life—in 1854—a determined attack was made upon it in Parliament. The defence by the Government was half-hearted, and the Board was discontinued by a majority of nine votes. It was afterwards reinstated on a somewhat different footing, but without Mr. Chadwick as secretary. His enthusiasm had started a good cause somewhat before its time, as far as public knowledge and opinion were concerned, and so the pioneer was sacrificed with some execration. But none the less it was Sir Edwin Chadwick who forced a Public Health policy to the front, and made the fine later progress possible.

A few words must suffice to bring organisation and legislative action up to date. Some of the more energetic corporations sought power over sanitation in local Acts, Liverpool honourably leading off, in 1846, with the appointment of its own Medical Officer of Health. London followed suit in 1848, and appointed Dr. (later Sir) John Simon, who since has been the historian of the Public Health movement. When, in 1855, the General Board of Health appointed a Central Medical Officer, and gave Public Health at last an official medical chief, Sir John Simon received the appointment, and held it twenty-one years, while the department passed, in 1858, under the Privy Council, and later under the Local Government Board, where it now remains.

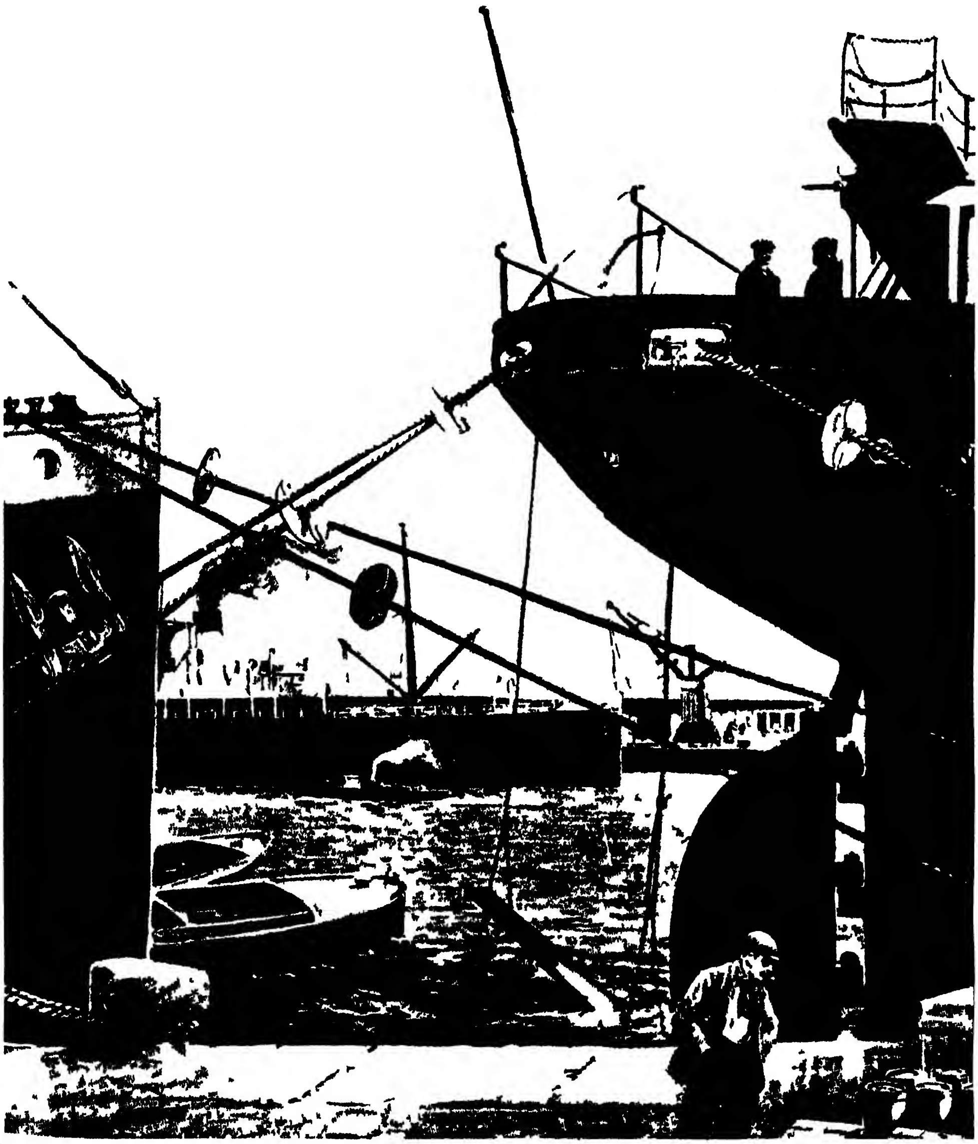
The Upbuilding of the Present Legal Basis for Securing Public Health

As time has gone on the demands of health have been strengthened through legislation. The Act of 1866 changed the wording from the futile "may" to the confident "must." Further, when sewers were not provided, or water supplied, or nuisances removed, the Court of Queen's Bench was given the power to enforce the neglected duty on local authorities. The Local Government Board was established in 1871, and all authorities were compelled to appoint Medical Officers of Health and Inspectors of Nuisances. The Notification of Infectious Diseases was made general but adoptive in 1889, and compulsory in 1891, and compulsory notification of tuberculosis by medical men was allowed in a local Sheffield Act in 1903. In recent years it has usually been the advanced and energetic local authorities that have led the way towards greater health security, and the central government and legislature that have followed.

We may here summarise, in briefest form, what has been accomplished since 1846, showing the wide range over which Public

Health control operates under various government departments. The country has been organised for sanitary administration into counties, municipalities, urban districts, rural districts, parishes and port authorities, with London as a separate organisation. The country has been fenced in from disease by regulations that treat a ship as if it were premises on land, and special laws have been made for inspection and detention of persons in case of infectious disease. The passage of rats to and from suspected ships must be stopped by guards placed on cables, as pictured on this page, and alien immigration is safeguarded so that it does not introduce disease.

Every medical officer must have a distinct qualification for his work by study and experience. Not only are a multitude of points dealt with by the general law, but local by-laws have the force of law. Under such by-laws come regulation and inspection of lodging houses, slaughter-houses, dairies, cowsheds, and milkshops.



DISCS PLACED ROUND HAWSERS OF FOREIGN TRADING SHIPS TO PREVENT THE EGRESS OF PLAGUE SPREADING RATS

Not only are the making and the soundness of sewers regulated, but in the case of private drainage works the local authority may open questioned drains, execute the necessary work, and recover the expense. Disposal of sewage is regulated, and the pollution of rivers guarded against. A local officer can demand the inspection and testing of the sanitation of any house, and a drain may be compulsorily made if a sewer is within a hundred feet of the boundary of the land on which the house is situated.

The Scope of Some of the Laws that Now Preserve the Public Health

The range of the word "nuisance" has been extended and more clearly defined, and methods of procedure to abate nuisances have been established. The water supply has been brought under the supervision of the local authority. The Act of 1878 makes it the duty of every *rural* sanitary authority to see that every dwelling-house within their district has within a reasonable distance an available supply of wholesome water sufficient for the use of the inmates of the house. Local authorities are themselves empowered to provide public and private water supplies by the Act of 1875.

As regards scavenging and cleansing the streets, every local authority *may* -and when required by the Local Government *shall*—remove house refuse, cleanse closets, and clean and water the streets.

One medical officer, or two medical practitioners, or ten inhabitants of a district may insist that magisterial proceedings shall be taken by an urban sanitary authority against those who carry on a trade process that is a nuisance, or injurious to health.

Unsound food may be seized, and those who exposed it for sale summoned; and there is a series of Acts against the adulteration of food and drugs, with very heavy penalties attached.

Steps for the Discovery of Disease, and for Its Prevention

The notification of infectious diseases to the Medical Officer of Health by medical practitioners, and, if necessary, by private persons, is compulsory. Power is given to local authorities by an Act of 1897 to cleanse verminous persons; and disinfection of clothes and houses has become a regular part of the work of every up-to-date Health Authority.

Besides these forms of surveillance and suggestion, restriction, and compulsion, for the good of all, there are five great blocks of legislation having the same objects in view that served as an inspiration to the pioneers, Edwin Chadwick and Southwood Smith, in the middle of the nineteenth century, and more than fulfilling their dreams.

Under the Housing of the Working Classes Act, unhealthy areas may be closed in the towns, and healthy dwellings be erected in their stead; and the Town Planning Act of 1909 - an extension of the Housing Act—gives facilities for laying out towns, so that the slum may be a thing of the past.

Then the Factory and Workshop Acts—a long series, from 1878 to 1907—provide for as healthy conditions of work as possible in all occupations, conditions enforced by frequent inspection.

Next, a most important part of the work of every well-equipped department of a Medical Officer of Health is care for infant life, exercised largely through a staff of qualified women inspectors and nurses. A great deal has been done, with unmistakably good effects, to conserve the tenderest child-life of the community.

Preparations to Preserve the Health of the Young, Before School Age and in Schools

The Midwives Act (1902) guards against ignorant practice by unauthorised people, the Notification of Births Act (1907) brings the newly born child within the knowledge of the Health Authorities; the Children Act (1908) prohibits baby-farming; and the medical men on the official staffs have thrown themselves with great enthusiasm into the work of training mothers how to rear children, and of treating the babies themselves when they are ailing.

Added to this public care for infancy comes the invaluable work of medical inspection and treatment in school clinics that has been organised in connection with the elementary schools, by staffs of School Medical Officers who usually work in close association with the Medical Officers of Health. Three times in every scholar's life a thorough examination of physical condition should take place- at the beginning, middle, and end of the school career—and a detailed record be made.

In this way parents hear, at no expense, of the exact physical state of their children, and are enabled to secure treatment for them when weaknesses are only just developing. With respect to eyesight, ear and throat troubles, skin affections, decay of teeth, cripples, the mentally defective, and the tuberculous, some of the more energetic education authorities provide treatment for the poor by specially

retained medical men, thus relieving the hospitals. It seems as if, through the school medical department, the whole physique of the nation would eventually be tested, tabulated, and possibly be brought under treatment where necessary.

Then, lastly, there is the pecuniary interest in the health of the whole of the working classes that is involved in the Insurance Act. It was felt in the days of neglect of health that disease could not be afforded by the community, and that, probably, was the most effective argument for reform with the thrifty ratepayer. Now the illness that keeps a man from his work cannot be afforded, and therefore healthy surroundings must be ensured. More and more it will be seen that the preservation of health is the greatest of all economies.

The Vast Volume of Medical Treatment Under the Poor Laws

And all the while that this work of preserving the public health has been developed by the Legislature, the Local Government Board, Home Office, and Municipal Authorities, the Poor Law Authorities, through their infirmaries, have been treating great numbers, dividing in this respect the work of alleviating suffering with the voluntary and municipal hospitals. This task of the workhouses often escapes observation. The public fever hospitals are well known, and the accident and other hospitals are held in high regard, but it is not realised that, in round figures, there are a hundred thousand patients, including the aged and infirm, in workhouse hospitals, who are cared for by more than seven thousand nurses, and that these institutions are great training-schools for those who attend, expertly, on the suffering poor. This is irrespective, of course, of the enormous public service of the rate-supported lunatic asylums.

A New Lesson in Cleanliness from Old Japan

The impetus given in the eighteenth century to the study of medicine led to a great extension of the hospital system. For instance, Guy's was founded in 1725, the Westminster in 1719, St. George's in 1733, the London 1740, and the Middlesex 1745, but the voluntary hospital system now seems to be reaching exhaustion point, and its future is one of the great problems of public health policy.

The recognition of the necessity for the public, in its collective capacity, to deal preventively and curatively with diseases that come largely because disease is fostered by collective life, and also in order that the healthy may be protected from the infections disseminated by the sick, has been admitted by all civilised nations; and illustrations of the extension of this beneficent and indispensable work might be drawn from every quarter of the world. Perhaps the most striking could be found in Japan, where hygiene and medical treatment according to the new knowledge have had remarkable developments. The Japanese have realised that dirt is the arch-enemy of health, and have given it no quarter. In their crusade of cleanliness they have boldly brushed aside the idea that the liberty of the citizen allows him to be a nuisance and a danger to other citizens. Whole cities have been made clean "by order," with the result that the epidemics of the East have been repelled, for they have found no seed-beds of filth.

This war against disease, carried on by the wisdom of the whole community in disregard of the ignorance of the individual, though so long delayed, has made incalculable successes in the last sixty years in the extirpation of some diseases, the weakening of the power of other diseases, and the prevention of untold human suffering. How can the work be carried further to completion in the near future?

Questions of Future Policy in Public Health for Thoughtful People

Many questions bearing on this inquiry have been discussed already in our Eugenics section. Here we shall only refer to some that are involved specifically in the relation of Society, as a whole, to disease. What further restrictions should be imposed on individual action in the interest of the general health? What tuition of the public is necessary? To what extent should public authorities give medical treatment at the public expense? Would it be well to take over the whole of the hospital service, except where there is a substantial financial foundation for a hospital? Can the health of the generations to come be affected greatly for the better by the restriction of birth among the obviously unfit? Would it be well to have a complete State service of doctors? These are all questions on which the average citizen ought to begin to form a careful opinion after a thoughtful examination of the facts. They are ripe for settlement, for in almost every case a principle has already been conceded by legislation and practice, as we will show in our next article.

Of course, there will always be private doctoring for those who can pay for what is reputed to be exceptional skill. We shall

never be limited in this country to State, or official, doctors. It will be necessary, in order to preserve free opinion and inquiry, and the advantage of widely divergent points of view, and warring instincts—all excellent things in the main—to have an untrammelled body of medical practitioners. The dangers of knowledge wholly official and exclusively expert would be great. In no department of human inquiry have theories been more obstinately stereotyped, for a brief time, and then more rapidly abandoned, than in medicine. It would be far more readily possible for a band of State doctors to be all wrong together than for the profession as a whole to be wrong if many of its best men were independent.

Then, too, the tendency of State experts is towards an idealism irrespective of cost, which wears out the patience of the unideal man who pays, and throws back causes that, at their core, are wise and just. But however we may see the need for watchfulness against a too strait officialism in medicine, there can be no doubt that the general trend of the times is towards a State medical service, with payment for helping to keep men well. Society is organising its health as a great co-operative unit, and will organise hygienical and medicinal treatment on the same lines, with a much larger network of public hospitals as a more open training-ground than the present hospital system favours. And the eager scientific spirit in which the present public medical service—through the Local and Central Health Departments—has been carried on gives those who have watched it great confidence in the ultimate results. Tested by the quality of their public spirit the medical men who are already serving the State shine brightly.

A most hopeful sign of the times is that the medical profession, with the State hygienists of all varieties, have gone back in their science and doctoring to very simple natural laws. Cleanliness, pure water, fresh air, easy minds, are their great remedies, helping the inward healing powers so little understood. The whole course of health legislation for the last sixty years, over which we have cast a glance, has been giving Nature her chance—thanks to wise scientific advice—by opening out houses, factories, and spaces for free air, carrying off poisonous waste, bringing to everyone cleansing and health-giving water, and cheering the hearts of men with hope and brightness. These are the great and cheap specifics. How can their use be extended?

WHERE THE COMMUNITY CARES FOR THE SICK—A WARD IN A WORKHOUSE INFIRMARY

THE EUGENICS CONGRESS

A Summary of the Points Discussed at the World's First Great Conference on Eugenics

PERSONALITIES AND PROPOSITIONS

EUGENICS is a science and a practice which grows and changes as we study it, and we cannot possibly present an ordered and uninterrupted statement, as of some such science as geology. We are at present concerned with Positive Eugenics, the encouragement of worthy parentage, and we have seen how many first principles, of law and liberty and love, require to be settled before we can proceed on any effective scale. Let us now turn somewhat aside, for further guidance, to an unprecedented event which took place in London in July, 1912.

The First International Eugenics Congress was not entirely the first of its kind, for a conference which comprised representatives of various countries had already been held in Germany, under the auspices of the German Society for Race-Hygiene, which is none other than eugenics. We are greatly indebted to Germany in this respect. The society in question was the first of its kind in the world, and its journal has long been a source of new knowledge for Eugenists. But the congress held in the University of London in 1912 was certainly the first to rank as a congress of experts and amateurs from all parts of the world.

First, as to the progress of our idea. The late Sir Francis Galton introduced the word "eugenics" in 1884. He met with no response whatever, and turned aside to other matters which promised to be more immediately fruitful. Twenty years later, in 1904, he was approached by the then newly formed Sociological Society, with the request for a public lecture upon eugenics. Those of us who belonged to that society thought that the time had come to launch eugenics into the waters of public opinion, and we believed that our society would be a fitting stage for the purpose. Galton accepted our invitation, and addressed a small company, in a classroom of the University of London, on "Eugenics: Its Definition, Scope, and Aims." None who were present will ever forget that occasion, and it determined the course of the present writer's life and work from that moment onwards. But the beginning, judged in the world's terms, was humble and unpromising, especially since the chairman, who is now Galton Professor of Eugenics in the University of London, expressed the view that the occasion was premature, and could serve no good purpose.

Little more than eight years later, when the founder of eugenics had passed away (early in 1911), we witnessed, in the International Congress, surely one of the most rapid and magnificent developments from a small beginning that the world has ever seen. Galton was gone from us, so far as the flesh is concerned; and a kinsman of his, Major Leonard Darwin, a son of Charles Darwin, who showed whence man has come, and hence how far he may go, was our president. A simple but worthy medal was struck, with the features of Galton upon it. The civilised world at large was represented. The number of members and delegates went well on towards a thousand. Learned societies, charitable societies, universities, Governments, and Government departments from all over the world sent delegates. The list of vice-presidents comprised illustrious names in jurisprudence, science, government, from all parts of the world. From our own country there were such names, for instance, as those of Lord Alverstone and Lord Avebury, and the present Home Secretary and his predecessor. The Congress included delegates, readers of papers, and members from France, Germany, Norway, Sweden, Italy, Spain, Switzerland, the United States of America, Japan, India, aud many other countries. If these facts

are insisted upon here, it is in order to show the absurd and inexcusable behaviour of certain writers who have represented the congress as an assemblage of irresponsible fanatics, fools, and enemies of morality. So to do is incidentally to throw the most egregrious insults against such men as Lord Alverstone, Sir William Osler, Lord Avebury, and scores besides, whose names and record are beyond question. While Mr. McKenna and Mr. Winston Churchill were vice-presidents, Mr. A. J. Balfour proposed the toast of welcome to our foreign guests at the inaugural banquet; and as that event was first in order of time, and has been most widely misrepresented, we may proceed to discuss it forthwith.

The Want of Ethical Significance in the Terms "Fit" and "Unfit"

Mr. Balfour wished success to eugenics, in which he has taken a steady and increasing interest for several years, and he declared that its advocates were now in possession of a large and solid body of evidence which could no longer be gainsaid, and such that no one is any longer entitled to form a judgment upon eugenics until he has himself examined and weighed that evidence. Mr. Balfour pointed out what the present writer has been urging for years - that the terms "fit" and "unfit" have no connotation of goodness or badness, worth or unworth, but simply refer to the environment. Natural selection tends to produce fitness- that is to say, adaptation to the environment. But, as Mr. Balfour said, it may thus produce very fine things or very unpleasant things. He showed, as it is so easy to show if one has really read the pages of Darwin, that the terms "fit" and "unfit," which Eugenists are so fond of using, may mean anything. Thus, if the feeble-minded increase today, that shows that they are the fittest under the environment of modern social conditions.

The True Distinction in Eugenics Between Worth and Unworth

Nearly everyone laughed at this, and Mr. Balfour practically reproved the company, saying that he was perfectly serious, and that it was not an ill-timed jest. Of course, it was not; it was simply the *reductio ad absurdum* of the argument from natural selection which is advocated, not by biologists, nor by doctors, but by those who have never really grasped the Darwinian theory of adaptation by natural selection.

Readers of this section of POPULAR SCIENCE need no further discussion of the matter. The terms "fit" and "unfit," which mean nothing in eugenics, whatever may be the case in biology, have never been employed here. The concern of eugenics is with worth and unworth — ethical and social ideas which have no meaning in the realm where "natural selection" reigns. But one excellent result of Mr. Balfour's observations was that we heard practically nothing of "natural selection" at the congress, or of the brutal teaching to which we are led if we follow the gospel of murder and destruction in our effort to preserve and to create. Indeed, the silence of the "better dead" school was, in the present writer's judgment, the most remarkable feature of the congress.

Closely allied or identical with this party are those who preach of class-eugenics. The whole tendency of the congress and of the papers was against such an unscientific and vicious perversion of our creed. Again and again speakers were applauded who protested against the assumption that the more fortunately placed classes are biologically superior. So far as somewhat careful observation could show, there seems to be no evidence of class-eugenics as the creed of Eugenists in any other country than our own.

The General View that Class Prejudice has no Biological Warrant

In Republican France and America, which stand for rebellion against the dominance of a pseudo-aristocracy, we could scarcely expect to find those ideas which Mr Whetham, of Cambridge University, expresses when he declares that class prejudice has a biological warrant and basis—an opinion, by the way, which he omitted to state at the congress. Here we have already studied with especial care the splendid, original, and invaluable contributions of the American students to our real knowledge of human genetics. We have seen that Mendelian analysis, so far from warranting any generalisations about class, shows the necessity of sharply distinguishing different individual members of the same stock, even children of the same parents. In the light of the American work the view of eugenics as a new argument for the veto of the House of Lords, or against death duties, simply cannot be maintained. Whatever may be the merits of those questions, eugenics knows no arguments on the side of the privileged classes, because it knows no arguments for or against any social stratum as such.

In the United States every kind of eugenic or dysgenic experiment has been tried; and those who have first-hand opportunities for observation there know better than to

countenance the pernicious rubbish which is too often uttered in the name of eugenics here. One of the tests of "fitness," in the language of many Eugenists in this country, is "success." In the United States of America they have seen a good deal of success and the qualities that make for success. If we can observe an aristocracy, so called, they can observe a plutocracy, a caste which embodies the kind of "fitness" that produces success. But no one who wishes to retain a reputation for decency of feeling will be likely to tell an American that these are the qualities, and these the kind of people, which eugenics wishes to encourage. In America there has been indeed tried, on a huge scale, the very kind of unfettered competition with huge prizes for the qualities that win in such competitions which a school of Eugenists in this country is always demanding as the only means of breeding a "fit" race. The results are so entirely deplorable, so disgusting to all honest and decent people, that the last place in the world whence this kind of preaching can proceed is the place where it has been practised.

It was a great privilege for us in this country to meet so many distinguished American students, for whose work we have had so much reason to be grateful but it was a greater matter still to have the whole weight of their national experience and feeling and knowledge thrown against the brutal and arrogant teaching which has lately disfigured so much of our eugenic propaganda in this country.

The verdict and consensus of the Continental delegates was similar. The paper on practical eugenics, by Professor Querton, of Brussels, dealt almost wholly with what we here call Nurtural Eugenics—the care of the child and the nursing and expectant mother. The opposition between the claims of Nature and those of Nurture, which has been so often assumed in this country, as if every characteristic of every living creature were not a product of both, found no exponent among the foreign contributors. The interesting and valuable papers which came from France showed no sign, of course, of any belief in the sacred character of class; and, as might also be expected, they included a full recognition of the importance of nurture, especially in the earliest stages of development. In her care of the infant, of the nursing mother, and finally of the expectant mother, for her own sake and her child's, France has taught the whole world, and it was impossible that any support of the "better dead" theory should come from that quarter.

MAJOR LEONARD DARWIN

Scarcely less notable than the failure of the brutal school to display itself or to find foreign support at the congress was the complete disappearance of the school of "biometry." The strange fact has to be recorded that at the First International Eugenics Congress, held under the auspices and in the buildings of the University of London, the occupant of the Chair of Eugenics in that University, the only Chair of its kind in the world, was absent.

No paper was read, no contribution to the discussion made, in which the "biometric method" was employed, or its results accepted. We shall later see how the biometric study of the influence of parental alcoholism upon the offspring fared at the hands of the congress. Galton himself was the pioneer of the method which is now called "biometry," and he believed in it to the end. "Galton's law" of ancestral inheritance has disappeared from the interests of men of science. The whole method which depends upon the aggregation and therefore the inevitable confusion of different stocks, the only method recognised in eugenics as at present officially prosecuted in the University of London, was as if it had never been at the congress.

On the other hand, the place of Mendelism

or what we now call genetics, was recognised by speakers from all countries. Professor Punnett read a paper on genetics and eugenics; and there was no question, from first to last, that we must henceforth base our eugenic assertions upon the sure ground of genetics, which Mendel began to prepare half a century ago.

The chief permanent contribution of the congress to eugenic thought is found in the volume on "Problems in Eugenics," and it is interesting to wonder how this volume will appear, say, when the congress next comes to London, perhaps not for fifteen years at least. Some striking omissions from the volume may well be noted—both those which we may welcome and those which we must deplore. In the first category we have already referred to the disappearance of biometry, which, by the irony of fate, had no sooner been established in the University of London than it had become obsolete.

The other conspicuous omission of this class was the whole problem of tuberculosis, which has been the subject of so many disastrous assertions, in the name of eugenics, in this country. Those assertions would have been impossible if the help and interest of the medical profession as a whole had been earlier enlisted in the eugenic campaign. Such help and interest are beginning to appear, but hitherto the spokesmen of eugenics have largely been those who had no first-hand knowledge of such a medical problem as tuberculosis. Even Sir Francis Galton, in a passage which we have recently cited here, is to be found speaking of hereditary pauperism, as if pauperism were a biological entity; and we can scarcely be surprised if many of his followers have been inclined to think and speak similarly of the disease which is so closely associated with poverty.

The most strenuous efforts have been made, in a series of papers issued by Professor Karl Pearson, to show that the factor of infection is of little moment in tuberculosis, and that the all-important factor is inherited and transmissible susceptibility. On this ground, curiously enough, Professor Pearson has argued against the provision of sanatoria for consumptives, as useless and even disastrous, because the only fashion in which we can rid ourselves of tuberculosis is by letting it weed out the susceptible strains in the community. If the professor's prejudice against all measures of social reform that do not regard heredity as the only factor of importance in human affairs were not so extreme, he would see that the provision of sanatoria must be a eugenic measure on his principles, by interfering with parenthood on the part of those who inhabit them. Sanatoria go far towards establishing for the tuberculous the principle of segregation which Professor Pearson and all eugenists demand for the feeble-minded, and are therefore, on Professor Pearson's own theory, the best method of extirpating the disease by opposing parenthood on the part of the tuberculous. But, unfortunately, sanatoria have been advocated on other grounds and on other assumptions which Professor Pearson cannot endure.

PROFESSOR PUNNETT

Photo by J. P. Clarke

The Eugenics Congress, with its assemblage of experts in genetics and in medicine from all parts of the world, where tuberculosis is being dealt with in a variety of ways, and in a great variety of climates and human stocks, would have been the ideal opportunity for the presentation of Professor Pearson's conclusions on tuberculosis. But, as we have seen, he would have nothing to do with the congress; and, in fact, the whole problem of tuberculosis was there ignored. The first-hand students of the disease, both in human beings and in cattle, are only convinced of two very simple facts—that it is an infection, and that it can be controlled by control of the infection. If anything is to be known as regards inherited and transmissible susceptibility, no one yet knows it. It is quite possible, the writer would point out, that the poisoning of the parental body by the infection may prove

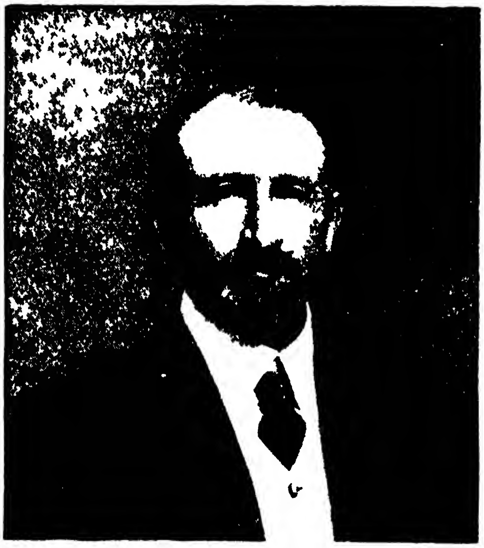
to be a racial poisoning, so that the subsequently born offspring may be weakened and predisposed towards the disease. That is a very different thing from a genetic predisposition, which will be handed on to offspring even if the individual parent himself escape the infection.

At the present moment there exist no *data*, least of all those relied upon by the biometricians, where all the factors of the disease are jumbled, by which we may determine the existence of genetic susceptibility to tuberculosis, if such there be. The existing evidence, upon which the biometricians rely, is as conclusive regarding heredity as the similar data, which anyone may collect, regarding cholera or mumps or ringworm, or any other infection, grave or trivial.

Other omissions from the programme were not so satisfactory. Eugenic education should lead on to eugenic marriage, which is, of course, the immediate instrument of positive eugenics. But the whole problem of marriage, the conditions of it, as well as preparation for it was ignored at the congress. The legal and social conditions of marriage vary so widely in different parts of the world, and these variations must bear so closely upon eugenics, that a most valuable and important discussion of the subject might have been initiated. Scarcely less unfortunate was the omission of any paper on the feeble-minded, another problem of urgent interest in this country. Many parts of the world are far in advance of ourselves in this matter and their experience would have been most valuable.

The question of the birth-rate was discussed and constantly referred to, and nothing revealed wider discrepancy of eugenic opinion. We had representatives from countries like France, with its low birth-rate and sparse population, from densely populated Belgium, from Germany with its high birth-rate, and so forth. From all or most of these countries we had advocates of a low birth-rate, and those who deplored the fall which is occurring in all civilised countries. No one can say that there is any general eugenic verdict on this subject. We had Frenchmen deploring the fall of the birth-rate in France, on which a Government Commission has just been appointed, and Englishmen pointing to the prosperity and general wealth of France as a proof of the value of a low birth-rate.

The most nearly definite contribution to the congress on the subject of the birth-rate was furnished by the well-known American statistician Mr. F. Hoffmann, who showed that the birth-rate among native-born mothers in America is far lower than among mothers from the foreign immigrants who incessantly pour into that country. The argument from these facts is that of what Mr. Roosevelt calls "race-suicide," the conclusion being that the "Anglo-Saxon" element must disappear from the population of the United States.



DR. ALFRED MJOEN OF CHRISTIANIA

Future congresses will be able to determine the truth of this conclusion. Meanwhile, one or two facts may be noted. The first is that these statistics of comparative birth-rates tell us nothing as to the trend of a population unless they take into account also the comparative death-rates of those born. We need again to remind ourselves of Darwin's observation that the fulmar petrel lays only one egg but is probably the most numerous bird in the world. The living content of that one egg *survives*. Mr. Hoffmann's inquiries did not extend, and comparative studies of the birth-rate hitherto never have extended, to what we require to know—the number of those born who themselves reach the reproductive age. It is, in point of fact, notorious that high death-rates and birth-rates usually go together. Everyone would admit that the death-rate among the infants of these immigrant mothers in the United States is far higher than among the children of native-born mothers. Until we see how this factor works out we cannot say whether the immigrant element does indeed show a greater natural increase than the native element in the United States.

And in our comments on comparative birth-rates of different sections or classes of the community, in this country or elsewhere—whatever our theory as to the comparative biological worth of those sections or classes—we require constantly to beware of drawing conclusions which depend upon the untrue assumption that the same proportion of those born survive to the reproductive age in all cases.

The present writer here by no means commits himself to or against the neo-Malthusian view of the birth-rate, which was most ably represented at the congress by Dr. Drysdale. But at least the neo-Malthusians have this to be said for them that the upward progress of life has coincided with a falling birth-rate, and an ever-increasing proportion of survivors among those born. The case of the fulmar petrel shows how foolish it is to estimate the increase of a race or species by its birth-rate alone and how eminently effective is attention to the survival of those who are born. For some reason or other the statisticians seem constantly to ignore this very simple fact. We have just noted how this omission deprives us of the chance of drawing final conclusions from Mr. Hoffmann's paper. Now we find M. Jacques Bertillon, the famous French statistician, in urging the importance of immediate action regarding the birth-rate in France, similarly ignoring, apparently, the fact familiar to students of infant mortality—that infant mortality is far too high in France, and might be very easily reduced. Measures in that direction would very speedily raise the *effective* birth-rate though no more babies were born. It may be that the French Commission on the subject—which concerns ourselves, with our huge and almost empty colonies, far more intimately—will come to some such conclusion.

The most important, original, and impressive paper read before the congress dealt with the influence of parental alcoholism upon the germ-plasm. It was contributed by Dr. Alfred Mjoen, of Christiania, and will require detailed reference when we come to deal with that subject, our knowledge of which it definitely advances. This remarkable paper made a profound impression upon the congress, above all when we heard that, since it was written and within a fortnight of the congress, the Norwegian Parliament had passed a law embodying Dr. Mjoen's demand for the classification of all alcoholic liquors according to their strength.


MR. F. HOFFMANN AND MR. P. VAN WAGENER

In an inspired survey of the work of the congress, which appeared in the "Times" on the following day, this paper was the only one referred to, with the following introduction: "Another direction which it is hoped legislation will immediately take is the classification of the strengths of alcoholic liquors sold to the public." The Eugenist who was first responsible for insisting that eugenics must recognise and deal with parental alcoholism if it is to be true to itself, and who was then regarded as a crank whose views would lead eugenics away from its real business, may well be astonished to find the place which this demand established for itself at the International Congress. The only pity is that no indication so clear and cogent was furnished us for the advance of positive eugenics, the encouragement of marriage and parenthood on the part of worthy persons. That is a problem which we must now try to deal with in some practical terms; but we cannot expect such success, at this stage, as will be attained in years to come, when the Eugenics Congress of 1912 will sound as remote, and its notions as inadequate, in our successors' ears, as those of Plato do in our own. For this was but the first of a series of congresses which will be maintained so long as man finds a home upon the earth and knows the highest end to which he can set himself.

A COSMIC BOMBARDMENT

How Twenty Million Meteors Rush Every Day Into the Earth's Atmosphere and are Burned Up by Friction

THE CELESTIAL MESSENGERS' STORY

A GREAT shower of shooting stars, which is a spectacle of astonishing magnificence, is of rare occurrence, but anyone who watches the heavens on a clear moonless night may see within an hour more than a dozen of these bodies appearing as swiftly moving points of light darting across the sky, and visible usually for somewhat less than a second. Besides these isolated examples, small showers, seen only by assiduous watchers, occur almost every night; but the chief displays of celestial pyrotechnics, including many thousands of shooting stars, and lasting throughout whole nights, occur at intervals with a regular periodicity.

Sir Robert Ball has an eloquent description of the extraordinary shower of fire on the night between November 13 and 14, 1866, which shows the impression that display made on the distinguished astronomer. "The night was fine," he says, "the moon absent. The meteors were distinguished not only by their enormous multitude, but by their intrinsic magnificence. I shall never forget that night. On the memorable evening I was engaged in my usual duty at that time of observing nebulæ with Lord Rosse's great reflecting telescope. I was, of course, aware that a shower of meteors had been predicted, but nothing that I had heard prepared me for the splendid spectacle so soon to be unfolded. It was about ten o'clock at night when an exclamation from an attendant by my side made me look up from the telescope, just in time to see a fine meteor dash across the sky. It was presently followed by another, and then again by others in twos and threes, which showed that the prediction of a great shower was likely to be verified. . . . For the next two or three hours we witnessed a spectacle which can never fade from my memory. The shooting stars gradually increased in number, until sometimes several were seen at once. Sometimes they swept over our heads, sometimes to the right, sometimes to the left, but they all diverged from the east. As the night wore on the constellation Leo ascended above the horizon, and then the remarkable character of the shower was disclosed. All the tracks of the meteors radiated from Leo. Sometimes a meteor appeared to come almost directly towards us, and then its path was so foreshortened that it had hardly any appreciable length, and looked like an ordinary fixed star swelling into brilliancy and then as rapidly vanishing. Occasionally luminous trains would linger on for many minutes after the meteor had flashed across, but the great majority of the trains in this shower were evanescent. It would be impossible to say how many thousands of meteors were seen, each one of which was bright enough to have elicited a note of admiration on any ordinary night." Such were the showers which were chronicled in olden times as heavenly portents, and are recognised by modern astronomers as recurring with wonderful regularity.

There is also a clearly marked and regular periodicity in the frequency with which isolated meteors fall, and appear as shooting stars. More than twice as many are to be seen during the early morning hours as in the evening, the maximum being usually about two or three o'clock in the morning; and more than twice as many fall during the latter half of the year as are visible during the earlier half.

We have already seen in many ways what importance meteors have received in modern astronomy; thus, they are regarded as the materials out of which worlds are formed; and we last met with them as the constituent elements of the

rings which encircle the planet Saturn. Shooting stars also are meteors, which encounter the atmosphere of the earth. A shooting star is a solid body, usually of iron or of stone formation, quite cold and dark. It enters our atmosphere from space, moving with an initial velocity of about twenty-six miles in a second. But the earth itself is moving at a speed of somewhat over eighteen miles in a second. Consequently, if the meteor is travelling in the opposite direction to the earth, so as to meet us, its apparent velocity may be more than forty-four miles in a second; but if it is overtaking us, its velocity relative to the earth may be not more than eight or ten miles in a second.

But this initial velocity relative to the earth, whether greater or less, is quickly retarded by the resistance and friction of the atmosphere into which the meteor has plunged; and the brilliant light, which is all that we usually see of the shooting star, is caused by the incandescence of its materials through the great heat evolved by the atmospheric friction.

The Velocity of Meteors and the Heat Generated by Them

It is calculated that the average velocity of a meteor on entering the earth's atmosphere is about a hundred times the velocity of a rifle bullet, and that the latter velocity is sufficient to heat the bullet by 10 deg. Fahr. in the course of its flight. Inasmuch as the heating power of the atmospheric friction is proportional to the square of the velocity of the flying object, the flight of a shooting star is swift enough to produce ten thousand times the amount of heat generated by the flight of a rifle bullet.

Such an enormous development of heat is of course many times more than sufficient to light up a small meteor, converting it first into a shooting star, and then swiftly dissipating its materials in the form of fine dust. And since the amount of light produced depends upon the mass and the velocity of the shooting star, it is certain that the mass of most of these bright evanescent objects is extremely small, perhaps hardly amounting to a grain in weight, for otherwise the light would be greater than it generally is. Occasionally, however, the atmosphere of the earth encounters masses so large as to survive the great heat developed by their journey through it, and they fall to the ground in solid form. Some of these greater meteors, when the fragments into which they have been broken by the fall have been fitted together, have been found to weigh hundreds of pounds. These great projectiles are, however, quite exceptional among meteors.

It has been calculated that twenty millions at least of these meteoric bodies enter the atmosphere every day. The overwhelming majority are not visible at all, owing to the presence of sunlight, moonlight, and clouds.

How Far Away Does a Meteor's Blaze Become Visible?

The above calculation is based upon the comparatively small number observed from any one point on the earth's surface throughout a clear, moonless night. But if those shooting stars were also included which are too small to be seen without a telescope, the estimated number would have to be increased twenty-fold. The astronomer who watches the skies with a large telescope sees meteors darting across the field of his vision with great frequency.

Exceptionally brilliant meteors, known as fireballs, when entering the atmosphere at the swiftest speed, become incandescent, and therefore visible, at a height of about eighty or a hundred miles above the earth's surface; those which are moving more slowly relatively to the earth begin to blaze at a height of about sixty miles; and ordinary shooting stars shine first at an elevation of about seventy-five miles. In the vast majority of cases the career of brilliancy is brief; most meteors cease to be visible at a height of about forty or fifty miles above the surface of the earth, though some fireballs are seen as far down as five or ten miles above our heads.

The length of the path travelled by a meteor during the period of its shining depends to a considerable extent on the angle at which it falls, and may be anything from fifty to a hundred miles.

The Illusion as to the Size of Meteors Because of Luminous Air

Shooting stars may usually be traced throughout a space of forty or fifty miles; but fireballs, especially when of the slower velocities, and when seen near the horizon, almost always traverse a path of over a hundred miles in length.

Some meteors, and especially the rarest and most resplendent fireballs, look very much larger than they really are. Indeed, their diameters sometimes appear to be as large as that of the moon, from which we should naturally judge that they had a real diameter of several hundred feet. But this is all an illusion which is easily accounted for. In reality, the very finest meteors,

when they enter the atmosphere, do not weigh more than, say, a thousand or at most a few thousand pounds, nor in all probability do their diameters extend to ten feet at the most. The largest single mass which has been seen to fall to earth—in Hungary, in the year 1866—weighed less than six hundred pounds. Many bright meteors are probably not larger than a grain of sand. The great amount of light produced is due partly to the glare of the momentary combustion, and partly to the fact that they are surrounded, during combustion, by an envelope of hot air and smoke that becomes luminous, and so greatly exaggerates their apparent dimensions.

The meteorites that reach the earth's surface are of great interest, as being specimens of extra-terrestrial materials, which can be inspected and analysed. A great number of these bodies have been found, many having been seen to fall, but by far the majority have been distinguished as meteorites because of their physical characters.

There is a valuable collection of meteorites in the Natural History Museum at South Kensington. All these masses are covered with a very characteristic thin dark-coloured crust or glazing, formed by the intense heating of their surface for the very short period of their passage through the air.

The Crust of Meteors—How, and of What, It is Formed

This crust is usually not more than one-hundredth of an inch thick, the thinness being due to the fact that the air through which the meteor rushes carries away the melted surface. No sooner is the incandescent film formed than it is removed, so that the meteor, on reaching the earth, has only a very thin film of glazing upon it.

This crust is actually a black glass containing many small bubbles; it consists largely of oxide of iron, and is highly magnetic. Occasionally there is also an inner layer of incompletely fused matter, containing particles of iron which have neither been melted nor oxidised. As a rule, the crust and the rest of the mass are clearly distinct from one another; they do not blend nor mingle, except where sometimes the glazing has apparently flowed through veins and fissures into the more or less crystalline mass of the meteorite. The crust is often of unequal thickness in different parts of the same meteorite, and forms ridges as the result of a flowing movement in the melted material. The forward part of the meteorite, which meets the pressure of the air with the greatest force, becomes the most readily and fully liquefied, and the molten glaze flows backward.

Another common peculiarity of the crust is the appearance of numerous small "thumb-marks" or depressions, sometimes all over the meteorite, and sometimes on certain portions of the surface only. These may be due to the action of the air in driving off small portions from the melted surface, or, as is more probable, to the varying effects of heat and air on the different materials forming the meteorite, the holes representing the burning out of certain more fusible substances during flight; but the cause has not, so far, been determined with anything like absolute certainty.

Successive Explosions of Meteors as They Dash Through the Air

The fallen masses, when found, present the appearance of broken fragments, being of irregular shape, and often having many angular points. The various fragments which were picked up from the meteorite that fell at Butsura were fitted together, and formed one complete mass of regular form, except for one corner. Most of the fragments were coated all over with the typical glaze, showing that the explosion which separated them took place early in the meteor's career through the atmosphere; in other fragments, however, the faces which fitted together were not crusted, so that these must have been split apart by a later explosion, when the velocity of the meteor, and consequently the production of heat, had been reduced.

By the time they reach the earth's surface, meteorites are found to be still hot, but not, as a rule, hot enough to char woody substances, nor soft enough to receive any impression of the surface upon which they fall. Instances are on record, however, in which the mass was found to be still glowing hot on reaching the earth.

A Record of the Best-Known Meteoric Falls that have Reached the Earth

The number of fragments in which a meteorite falls to the ground varies greatly; sometimes the mass arrives intact, sometimes in thousands of little pieces, but it is usually broken into several parts.

The following are some of the meteorites which have fallen in the British Isles, and are preserved in the South Kensington Museum: Thwing, Yorkshire, 1795; Launton, Oxfordshire, 1830; Aldsworth, Gloucestershire, 1835; Rowton, Shropshire, 1876; Middlesbrough, Yorkshire, 1881; High Possil, Glasgow, 1804; Perth, 1830; Mooresfoot, Tipperary, 1810; Adare, Limerick,

1813; Killeter, Tyrone, 1844; Dundrum, Tipperary, 1865; Crumlin, Antrim, 1902.

Meteorites fall, of course, in complete independence of weather conditions or of any other terrestrial circumstance. But the fall is often accompanied by loud and violent detonations; and these, together with the brilliant flashing of the fireball, give to the phenomenon a general character not unlike that of the loudest thunder.

The Resemblances in Cause and Explosive Effect Between Meteors and Thunder

The manner in which these effects are produced is, in fact, very much the same as the processes that take place in an ordinary thunderstorm. The air is violently displaced by the meteorite travelling at an enormous speed: and while the air is under tremendous pressure in front of the meteorite, and is at the same time raised to a very high temperature, there is a partial vacuum created behind the flying mass, and into this vacuum the air rushes from the front with a noise practically identical with thunder.

The heat generated by the resistance of the atmosphere to a meteorite travelling with the initial velocity of twenty-six miles in a second is many hundreds of times greater than that produced by the burning of an equal quantity of coal, and is far in excess of the heat required to melt the most refractory metals. The heat and the pressure together are answerable for the explosions of the meteorites.

Long trails of smoke are often observed following a fireball. They are doubtless due to masses of molten matter swept away from the surface of the meteorite and turned to vapour by the heat of the surrounding air. Fresh layers of surface continue to be thus fused and swept away until the velocity of the meteorite has become retarded to about two miles per second, when the heat and the rush of air are no longer sufficient to melt and remove the material, and the fused surface cools and solidifies, forming the characteristic crust.

A Description of a Great Aerial Bombardment in Mexico

A graphic account of the fall of the Mazapil meteorite, in Mexico, in 1885, which was given in "Nature," well illustrates the details of the phenomenon. "It was about nine in the evening, when I went to the corral to feed certain horses, when suddenly I heard a loud hissing noise, exactly as though something red-hot was being plunged into cold water, and almost instantly there followed a somewhat loud thud. At once the corral was covered with a phosphorescent light, and suspended in the air were small luminous sparks as though from a rocket. I had not recovered from my surprise when I saw this luminous air disappear, and there remained on the ground only such a light as is made when a match is rubbed. A number of people from the neighbouring houses came running toward me, and they assisted me to quiet the horses, which had become very much excited. We all asked each other what could be the matter, and we were afraid to walk in the corral for fear of getting burned. When, in a few minutes, we had recovered from our surprise, we saw the phosphorescent light disappear little by little; and when we had brought lights to look for the cause, we found a hole in the ground and in it a ball of fire. We retired to a distance, fearing it would explode and harm us. Looking up to the sky, we saw from time to time exhalations, or stars, which soon went out, but without noise. We returned after a little, and found in the hole a hot stone, which we could barely handle, which on the next day we saw looked like a piece of iron. All night it rained stars, but we saw none fall to the ground, as they seemed to be extinguished while still very high up."

The Sensations of Onlookers Witnessing Meteoric Falls

As is evident from the latter part of this description, the Magapil meteorite fell during one of the great showers of shooting stars. This does not often happen. Very few of the big showers have been known to yield meteorites.

The Thwing meteorite fell on the afternoon of a calm, hazy day, when there was no sign of thunder. A loud explosion was heard, followed by a hissing noise, and then by a shock as of some heavy body falling to the ground. The sounds were heard over a considerable area, and people came running out of the cottages to see what was the cause. A ploughman saw the meteorite fall, not far from where he was standing. It was found to have penetrated through the soil, and for several inches into the solid chalk beneath.

The Middlesbrough meteorite, which is of a low pyramidal shape, and measures five inches by six, with a height of three inches fell during bright sunshine on a calm, clear day. Its fall was accompanied by a rushing or roaring sound overhead. Three minutes after its fall it was found to be slightly warm when drawn out of the round, vertical hole it had made for itself. It is unusual for a

meteorite to penetrate the earth in a vertical direction. Most of the holes made by these bodies prove that the fall took place in an oblique direction.

The oldest existing meteorite of whose fall we have authentic record is still preserved in the Rathaus at Ensisheim, in Alsace, at which place it fell on November 10, 1492. It was regarded with veneration by the people, and an account of the occurrence was written and has been carefully preserved. The stone was hung in the church, where it remained for many years. It weighed originally two hundred and sixty pounds, and penetrated the earth to a depth of five feet.

THE WILLAMETTE METEORITE FROM OREGON, SHOWING THE PITS FORMED BY OXIDATION

Meteorites may be divided broadly into two classes, according as they are composed chiefly of stone (aerolites) or chiefly of iron (siderites), but between these two kinds there is a great variety of combinations of the two. Sometimes the iron forms a sort of spongy framework or skeleton within which stony masses are embedded; sometimes, on the contrary, the stone forms the basis, and larger or smaller masses of iron are disposed throughout it.

Meteoric iron is an alloy that is not represented among the mineral products of our earth; it consists of from 80 to 95 per cent of iron, combined with from 6 to 10 per cent of nickel. The presence of nickel gives to meteoric iron a whitish appearance, and prevents the outer surfaces from rusting, as ordinary iron rusts. More than a dozen of the mineral constituents of meteorites have not been so far discovered among terrestrial minerals. Meteoric stone, on the other hand, is composed of minerals which are found upon the earth, in lava and other volcanic products. It is specially notable that carbon is occasionally present in the form of indistinctly crystallised diamond, and in one meteorite which fell in Russia minute portions of crystallised carbon identical with the black diamond were found. Carbon is sometimes present also in the form of graphite. Many of the common mineral compounds of our earth are, however, entirely wanting in meteorites; for instance, quartz, the commonest of terrestrial minerals. No free quartz in any form has ever been found in a meteorite.

The chemical elements of meteorites are, however, all represented among our known chemical elements, and are almost all common among these. About one third of the known terrestrial elements, including helium, have been found in these bodies.

The most frequent, or most plentiful, are iron, nickel, magnesium, calcium, aluminium, carbon, oxygen, sulphur, silicon, and phosphorus. Less frequent, or present in smaller quantities, are hydrogen, manganese, cobalt, copper, lithium, sodium, potassium, strontium, titanium, chromium, tin, arsenic, antimony, chlorine, nitrogen, vanadium; and occasionally minute traces are found of gold, silver, platinum, lead, gallium, and iridium. Iron occurs almost always, as we have said, in combination with nickel; phosphorus almost always in combination with these two.

The Extraordinary Train of Light which may be Left by a Fireball

No trace of organic matter of any kind has ever been discovered in meteorites; they bring us, therefore, no evidence of any living beings beyond our earth.

We have already seen that the fall of a meteorite is often accompanied by the appearance of a fireball, but many fireballs sweep across the sky without yielding, so far as we know, any meteoric fragments. A fireball is a shooting star of exceptional size and brilliancy, and is usually more or less pear-shaped. It appears with startling suddenness, and resembles a superb mass of liquid fire moving across the sky and falling earthwards in a sweeping curve. Not infrequently a fireball leaves behind it a train of ruddy sparks or a curved streak of light, and this luminous train often remains for some minutes, and has been observed as long as forty-five minutes after the passage of the meteor.

The Origin of Meteorites neither Terrestrial nor Atmospheric, but Cosmical

Both the path of the fireball itself and the form of the trail which it leaves behind it show irregularities in their curves, due to the force of the currents of air. Some fireballs move as swiftly as ordinary shooting stars, but the finest ones move much more slowly; they radiate, as a rule, from near the horizon, and pursue a more or less horizontal path of a hundred miles or more in length before they disappear. A particularly resplendent fireball was seen during the famous star-shower of November, 1833, over the Falls of Niagara. It was of great size and beauty, and had the appearance of remaining for some time almost stationary high over the Falls, giving off radiant streams of light in all directions. If a fireball falls in the daytime, the ball of fire and the train are seen only as white clouds, their brightness being invisible in the far greater brilliancy of sunlight.

As to the origin of meteorites, it is now fully established that they are cosmical and not terrestrial nor atmospheric phenomena. The idea of stones falling from heaven was hinted at from the earliest times, but was scorned by men of science until comparatively recent years. The ancient popular belief is shown by the veneration given to such stones as the Greek Cybele and Diana of the Ephesians, both of them examples of meteorites. It is now known that inconceivable multitudes of these bodies infest space; that they move in regular orbits round the sun in accordance with the law of gravitation; that they are invisible to us until they enter our atmosphere and become ignited by the friction due to their passage through it; that, having entered the terrestrial atmosphere, they cannot again escape from it, but fall towards the earth, and are reduced to imperceptible dust; and that portions of some few survive the passage and fall to the earth's surface, providing us with practical evidence as to the physical nature of bodies outside our planet.

The Identity in Composition of All the Meteoric Masses

There is no reason to suppose that there is any difference between the nature of the meteors which reach the earth's surface and that of any others, including the showers of shooting stars. All these phenomena present the same features, although none of the great showers has been known to result in the fall of meteorites to the ground, with the possible exception of the Mazapil meteorite described above. Inasmuch, therefore, as we are able to put together what we learn from meteorites with what we learn from the showers of shooting stars, meteors form a most valuable source of knowledge, especially, as we shall see in a later chapter, in connection with comets, for the close relation between comets and shooting stars is amply demonstrated by the history of some of the great showers and of certain comets.

At regular times, as we have seen, meteors appear in great numbers, many thousands of them within a few hours, darting in all directions across the sky. But when these directions of flight are carefully observed, it is found that all of them, with perhaps a very few exceptions, diverge from one point in the sky, known as the radiant. All the lines of direction, if produced backward, meet in this point; and the position of this radiant among the fixed stars is the same from whatever place on the earth it is

observed. It is evident, therefore, that there is no actual point from which the meteors do, in fact, diverge. The effect is due simply to perspective; the meteors move actually in parallel lines and the radiant represents the "vanishing point." A line drawn from the radiant to the observer gives, therefore, the actual direction of these parallel lines. The position of the radiant depends entirely upon the direction in which the meteors are moving relatively to the motion of the earth.

Problems of the Direction of Meteoric Flights Solved and Unsolved

But the particles which constitute meteors are of extremely irregular form, and they are consequently apt to be deflected somewhat from their course when they enter the atmosphere; and, further, it is unlikely that they travel in precisely parallel lines. On this account the radiant is not actually a point but is a small area in the sky, which is seldom, however, as much as two degrees in diameter.

In the case of showers which last for days or weeks, the position of the radiant is found to move slowly among the stars night by night. This change is due to the change of direction in the earth's motion, and is exactly what we should expect, since the position of the radiant depends upon the combination of the direction of the earth's motion with that of the meteors. Some exceptions have, however, been observed. In some cases the radiant is found to maintain its position among the fixed stars, notably in the case of the showers known as the Orionids. This shower lasts from October 10 to 24, and its radiant point remains stationary the whole of this time. No explanation of this and other exceptions to the general rule has yet been found.

The Mapping Out of the Courses of the Meteorites

The radiants of about a hundred different recurrent showers are now catalogued. The most important of these are: The Leonids, November 13; the Andromedids, November 27; the Perseids, from about July 11 to August 20; the Draconids, January 2; the Lyrids, April 20; the Aquariids I., May 6; the Aquariids II., July 28; the Orionids, October 10 to 24. The names of these showers are of course derived from the situation of their respective radiants; for example, the Leonids all radiate from a point within the constellation Leo.

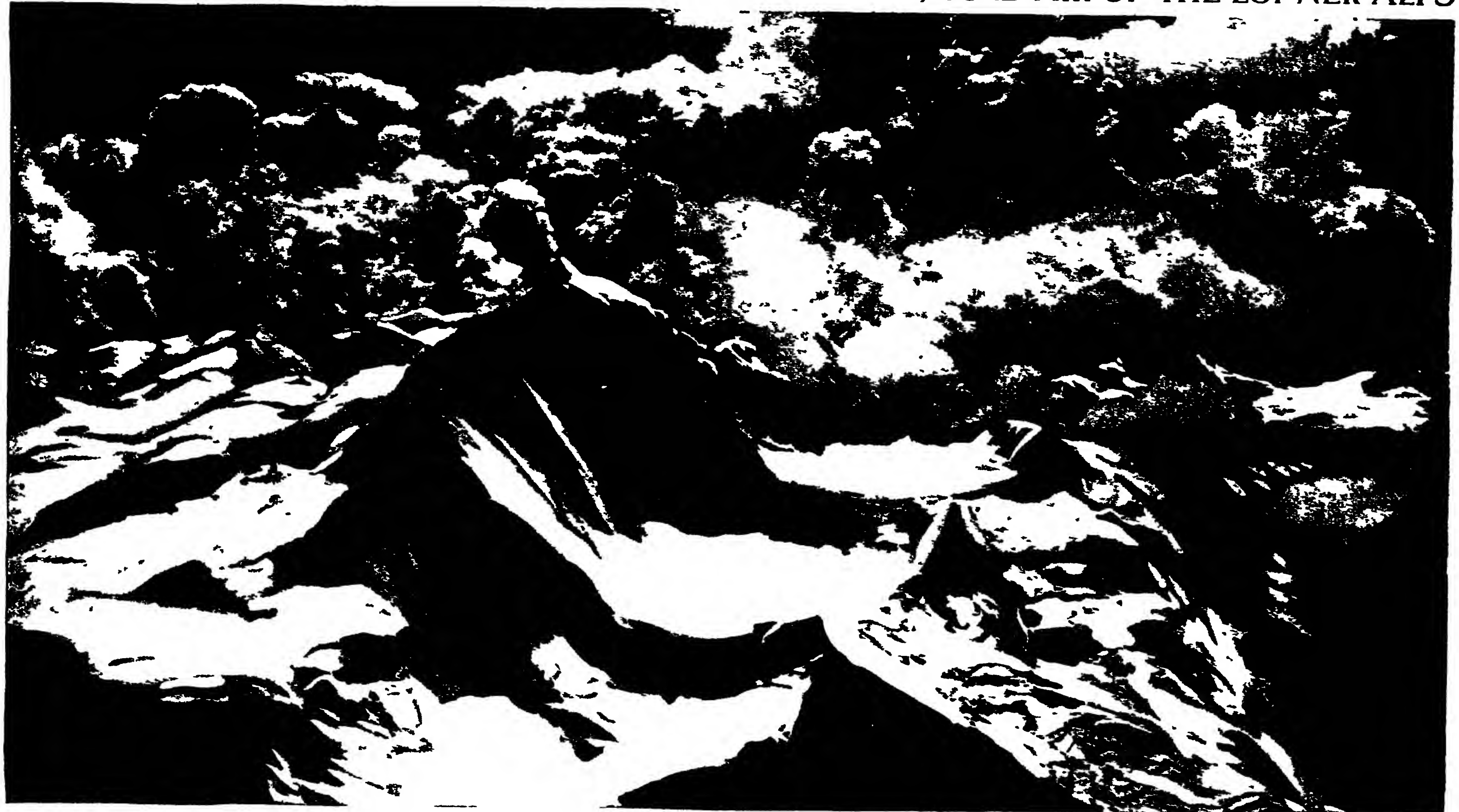
As early as 1811, some idea of a possible periodicity in the motions of meteors seems to have occurred to astronomers; and in 1833, when the fact of the radiant and its meaning were clearly recognised, Professors Olmsted and Twining, of New Haven, showed that this regularity of movement in a large swarm of meteoric bodies was evidence of their cosmical origin, and of their motion in regular orbits round the sun. It was Professor Newton who, just before the recurrence of the Leonid shower in 1866, completed very laborious researches which brought to light historical records of brilliant star-showers on sixteen occasions in October or November, the earliest on record being in the year 902 A.D. The dates are at intervals of thirty-three years or multiples of thirty-three years, while the day of the year has moved along the calendar at the rate of one month in a thousand years. Part of this alteration in date is accounted for by the change in the calendar, the actual variation in the date of the shower being about one day in seventy years. This gradual change of date implies a gradual change in the position of the orbit of the meteors, for if this had remained constant, the shower would always have crossed the earth's orbit in exactly the same place.

A Possible Explanation that Meteors Come to Us from Uranus

It was possible with much labour to calculate which of the planets would be able to produce the perturbations necessary to cause this change of orbit, and so to provide data for the determination of the orbit itself. From the direction of the Leonids, given by their radiant, and from their periodicity, it was found that there were five possible orbits for them one long ellipse which required the whole of the thirty-three years to traverse; two almost circular orbits, one a little longer and the other a little shorter than the earth's path; and two smaller ellipses contained within the orbit of the earth. The calculation of the perturbations required to produce the change in the orbit made it possible to decide that the great orbit of thirty-three years is the true one.

This having been determined, another very interesting fact emerged. The orbit of the Leonids does not intersect the paths of Jupiter or of Saturn, but it does intersect the path of Uranus; and Le Verrier showed that in the year 126 A.D. Uranus was at this place of intersection just at the time when the swarm of meteors was there. It is believed that this encounter fixes the date of the introduction of the Leonids into the solar system.

INTERACTION OF EARTH AND ATMOSPHERE IN THE THIN, COLD AIR OF THE LOFTIER ALPS



THE JUNGFRAU AND OTHER PEAKS OF THE BERNESE OBERLAND, AS SEEN AND PHOTOGRAPHED FROM A BALLOON

MOUNTAIN STOREHOUSES

The Great Ranges of All the Continents and the Solitary Peaks

EFFECTS ON NATURE AND THE MIND OF MAN

To the unscientific mind mountains are symbols of immensity and immutability, and men at all times and in all lands have regarded them with reverence and awe. On Mount Olympus were throned the gods; on Mount Parnassus dwelt the Muses; on Mount Etna were entrenched the Titans. On Mount Sinai the Law was thundered forth; on Mount Hira, Mahomet conceived his religion. Further east still we have the sacred mountain of Fusiyama, in Japan; while on Mount Meru sat the gods of India.

Even in modern, matter-of-fact times mountains move sublime emotions. Thousands make pilgrimages to Scotland, and Norway, and Switzerland, not merely to breathe the mountain air, but also to get spiritual refreshment from the mountain scenery.

> More it is than ease,
> Palace and pomp, honours and luxuries,
> To have seen white presences upon the hills,
> To have heard the voices of the eternal gods.

Every poet, every painter, has been inspired by the mountains, and some of the noblest pictures in art, and some of the finest passages in literature, have been born of the mountains. Were the earth flat it might be beautiful, but it would have much less grandeur and much less sublimity. Ruskin in a fine passage imagines a beautiful flat country suddenly becoming mountainous. He imagines a great plain, "with its infinite treasures of natural beauty and happy human life, gathered up in God's hands from one edge of the horizon to the other like a woven garment, and shaken into deep falling folds, as the robes droop from a king's shoulders; all its bright rivers leaping into cataracts along the hollows of its fall, and all its forests rearing themselves aslant against its slopes, as a rider rears himself back when his horse plunges; and all its villages nestling themselves into the new windings of its glens; and all its pastures thrown into steep waves of greensward, dashed with dew along the edges of their folds, and sweeping down into endless slopes, with a cloud here and there lying quietly half on the grass, half in the air; and he will have as yet, in all this lifted world, only the foundation of one of the great Alps. And whatsoever is lovely in the lowland scenery becomes lovelier in this change. . . ."

Indeed, it would almost seem as if the mountain scenery affected the character of the people who inhabit mountainous districts, for mountaineers are notably brave, and vigorous, and independent. Probably, however, the highland character is the result of struggle with an adverse and stringent environment, rather than the result of intercourse with the grand and sublime in Nature. Even the tourist realises that the mountains are not merely to be admired, but also to be conquered. Difficulties and dangers must always attract the combative spirit of man; and though the conquest of a Mont Blanc or a Matterhorn may to some seem to be waste of energy, the exercise of strength and courage and patience involved in mountaineering braces and invigorates the sinews of the mind as well as the muscles of the body.

But, in the first place, what is a mountain? At what height does a mound become a mount? That is a question that each land must answer for itself, for it is largely a matter of comparison. A small hill in a flat country, arising abruptly from the plain, may seem a veritable mountain to the dwellers on the plain. Thus, as Réclus points out, a little hill only 780 feet in height which rises from the level plains of Lower Pomerania impresses the inhabitants so much that they have named

it the "Mountain of Hell," while a little hill in Denmark only 557 feet high is named by the cheerier Danes the "Mountain of Heaven." In a general way, however, mountains must be some thousands of feet high to deserve the name.

As a rule, the higher mountains of the world are congregated into groups, and are arranged linearly in ranges and chains. Thus we have the Grampians, the Alps, the Apennines, the Andes, the Himalayas. In some instances, however, a high mountain stands up in splendid isolation. Thus in British Guiana the mountain Roraima, 8000 or 9000 feet high, stands by itself; and, fifty miles away, Mount Twekkway, a similar lonely mountain, rises almost as high. These isolated hills are really colossal earth-pillars made by rain, and of just the same nature as the small earth-pillars that are so common in the Tyrol. Other isolated mountains, such as Vesuvius and Stromboli, are of volcanic origin. But, as we have said, these solitary peaks are the exceptions, and most mountains are congregated into mighty communities. When we examine the great mountain communities we notice at once that their arrangement is markedly linear. The Alps run in ranks east and west, the Himalayas and the Pyrenees also run east and west, while the Andes, Apennines, and Rockies run north and south.

The ranks, of course, are manifold; and though most of the valleys correspond in direction with the linear extension of the mountains, there are numerous passes and transverse valleys that interrupt the linear continuity of the ranges. In the Alps there are many hundreds of distinct valleys; in the Canton Grisons alone there are about five hundred, forming a regular labyrinth.


THE GREAT WATZMANN, IN BAVARIA

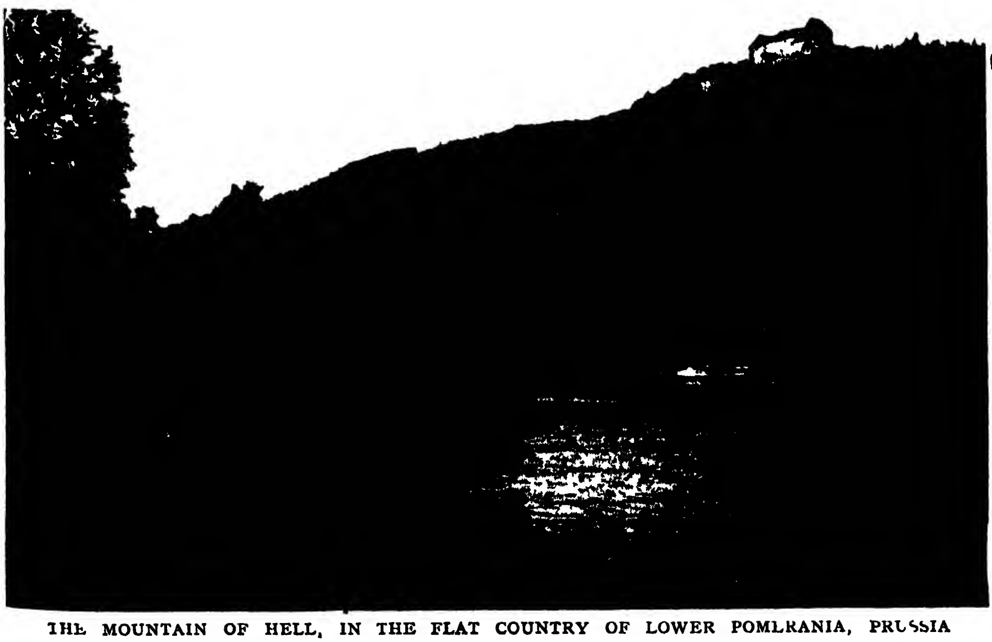
Let us look for a moment at the height and disposition of some of the great mountain ranges. The Pyrenees run between France and Spain, forming a great mountainous barrier between the two countries. From a principal double rampart of mountains running east and west, transverse mountain chains running north and south are given off, and these transverse mountain chains give off secondary chains at right angles to themselves, and more or less parallel to the principal rampart, the whole mountain system accordingly somewhat resembling the frond of a fern. Very few, if any, of the great mountain ranges of the world can be analysed into such a simple system. Most of the peaks of the Pyrenees are sharp and pointed, and the general effect is a serrated or dentate ridge. The average height of the peaks is almost 8000 feet, which is about 300 feet more than the average height of the Alps; but the Pyrenees are less striking than the Alps, because none of the peaks much outsoar the others.

The Alps are a much more labyrinthine and complicated series of mountains than the Pyrenees. Though the general trend of the range is east and west, its divarications and duplications are very numerous, and it can be divided into many more or less distinct systems, each with characteristics of its own. The central mass is the St. Gothard group, from which all the principal chains radiate, but the most magnificent group is the mighty rampart of Monte Rosa, whose peaks all exceed 13,000 feet, Monte Rosa itself exceeding 15,000 feet. Mont Blanc, the highest mountain of Europe, is 15,780 feet, but the average height of the mountains of its group is only 12,657 feet. Though the average height of the Alps is not so great as the average height of the

THE MOUNTAIN OF HEAVEN—THE HIGHEST ELEVATION IN DENMARK

Pyrenees, yet they are a much more striking system of mountains, because of the number of mountain giants, such as Mont Blanc, the Jungfrau, the Matterhorn, and Monte Rosa, which they contain.

The Himalayas is the most southern of a triple rampart of mountains running east and west across Asia, to the north of India. The most northerly range of the triple rampart is known as the Kuen-Lun, and the middle range is known as Karakorum. All three ranges are set on the plateau of Pamir, which is not unjustly called the "Roof of the World," and extend for a distance of 1550 miles, and have a breadth in places of 620 miles. The height of these three great ranges is tremendous. The peaks of the Karakorum have the greatest mean height; next come the peaks of the Himalaya, and lastly the peaks of the



THE MOUNTAIN OF HELL, IN THE FLAT COUNTRY OF LOWER POMERANIA, PRUSSIA

Kuen-Len. In the Himalaya range there are hundreds of peaks higher than Mont Blanc; while Mount Everest, or Gaurisankar (29,002 feet), is almost twice the height of that king of European mountains. Mount Everest is, of course, the highest known mountain in the world, but Dapsang, in the Karakorum, which is 28,271 feet high, and Kunchinjinga, 28,150 feet high, run it very close, while Dhawalagiri, 26,079 feet high, is quite a worthy rival. No other peaks in any other ranges can compete with giants like these; even the highest peak of the Andes is quite out-topped. Mountains over five miles high are not to be found in any other part of the globe. From this gigantic rampart range arise the Indus and Brahmaputra, and between the Himalaya and the Kuen-Len is the plateau of Tibet, which is 13,000 feet above sea-level, and measures 2000 miles from east to west, and 1700 miles from south to north. Though the Himalaya mountains are grander than the mountains of Switzerland, the scenery is not so picturesque and varied. "In all its grandeur, the Himalaya is uniform; its peaks are loftier, its snows more extensive, its forests deeper, but there are fewer cascades and lakes; there are no pleasant lawns and scattered groves, and we fail to notice the picturesque chalets nestling down in the glens, or hanging over the brink of the precipices." Owing to the height of the mountains and their situation in a warm climate, every climate is represented as we ascend the range. First we have a tropical climate with tropical flora and fauna, then a temperate climate with its flora and fauna, and finally we reach an Arctic climate with perpetual snow.

Since the great ranges run east and west they put a great barrier between north and south; and since neither north nor south winds can pass the barrier, there is a marked difference in the climates to the north and south of the range. Were the mountains removed, India would be cooler and Northern Asia warmer. On the other hand, it must not be forgotten that winds pouring downwards from the snowy peaks must, to some extent, mitigate the heat of the plains of Northern India. We shall deal later with the question of descending mountain winds.

MONTE ROSA AS VIEWED FROM ABOVE ZERMATT, SWITZERLAND

In North America we have the picturesque Rockies running north and south from Alaska to Tehuantepec, an average distance of 400 miles from the Pacific coast. Long's Peak (over 14,000 feet) and Pike's

THE MONT BLANC RANGE, SEEN FROM ITALY

A view of the "monarch of mountains" taken from the Combin de Corbassière. In the middle distance is a fine bergschrund, where the snow-bed parts from the rocks of the Pointe de Combin.

Peak are among the highest peaks in the Rockies. The range slopes gradually to the east, but more abruptly to the west; and parallel with it, to the west, with a wide plateau between, are the Sierra Madre, Sierra Nevada, and Cascade ranges, containing such lofty peaks as Orizaba (18,200 feet), Popocatepetl (17,500 feet), and Mount Whitney (14,900 feet), and in the far north Mount Logan (19,500 feet), Mount Wrangel (17,500 feet), and Mount St. Elias.

Running parallel with the east coast of North America we have the Appalachian mountains, or Alleghanies, a much lower range, whose highest peak—Mitchell's

THE PYRENEES, SHOWING THE TOWN OF LES EAUX BONNES AT THEIR BASE

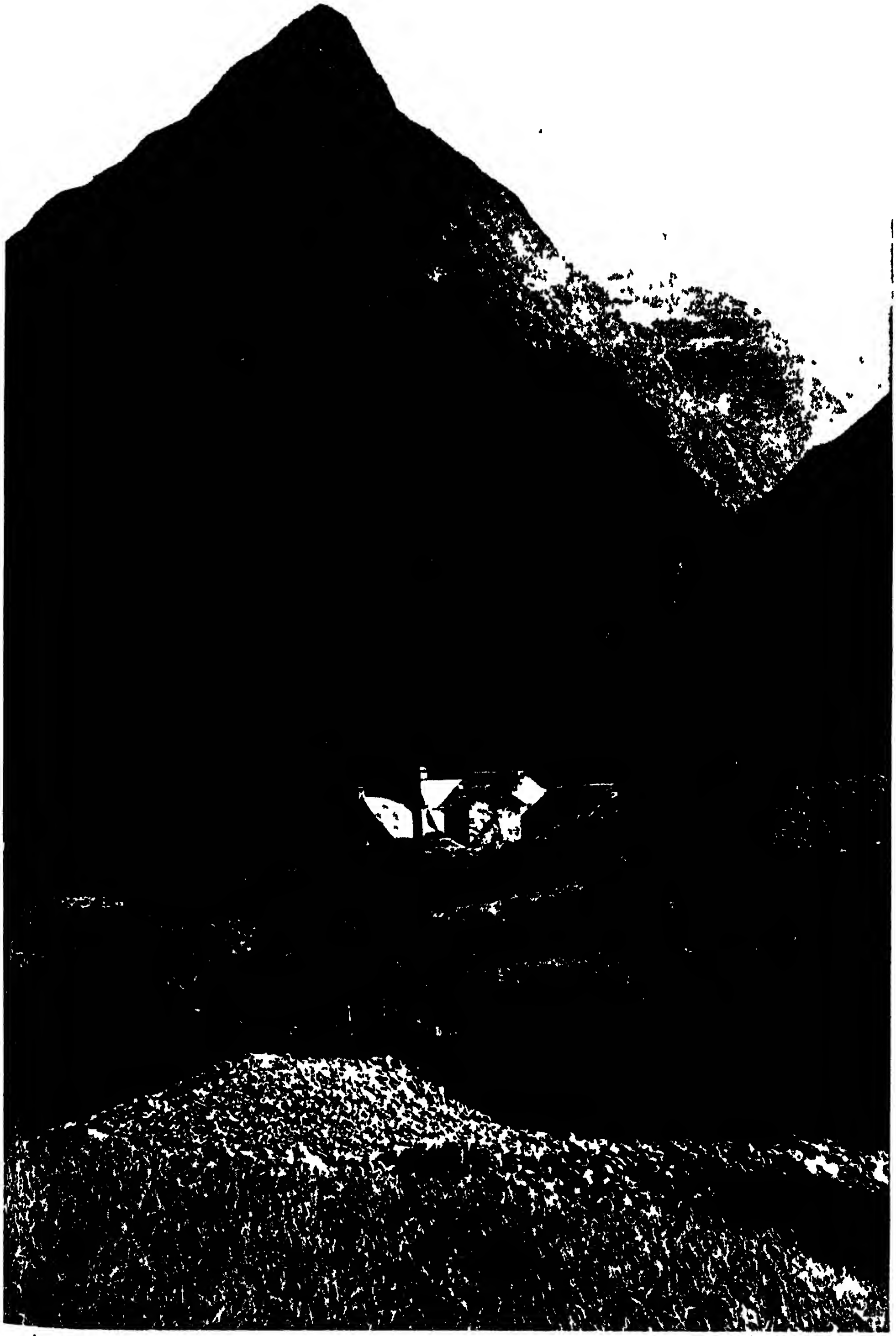
Peak—attains a height of only 6700 feet. In South America we have the magnificent range of the Andes, the longest and most continuous mountain system in the world. It runs north and south near the Pacific coast for a distance of 4350 miles. Though the average height of the peaks is considerably less than the average height of the peaks of the Himalayas and Karakorums, and though it contains no peaks that can rival Mount Everest and Dapsang, yet it is the second highest range in the world.

Its highest peak, Aconcagua, towers to a height of 22,400 feet above sea-level, and it includes at least thirteen peaks over 19,000 feet. The height of the range, too, is remarkably consistent. Most of its passes are 14,000 feet high, and the lowest pass in a stretch of 4000 miles is 11,400 feet. The range divides South America very unevenly, for its distance from the Pacific is 30 to 150 miles, while in places it is 3000 miles from the Atlantic. North of Aconcagua the range is double, and at one place the double chain includes a plateau as large as Ireland. South of Aconcagua the range consists of a single rugged ridge which gradually dwindles as it runs southwards.

In Africa there are almost no great mountain chains. The greatest chain is probably the Atlas Mountains, some of whose highest summits may reach about 14,000 feet. Most of the lofty mountains in Africa are volcanic. Volcanic, for instance, are the Cameruns (13,700 feet), Kenia (about 19,500 feet), Kilimanjaro (19,680 feet). Yet, strangely enough, despite its lack of mountain chains, the African continent has an average height of 1640 feet—equal to the average height of Asia, with its Himalayas and Karakorums.

Having thus glanced at the great mountain chains, let us look for a moment at the uses of mountains. The mountains play a very varied and important part in the

IN THE DESOLATE DAUPHINE ALPS

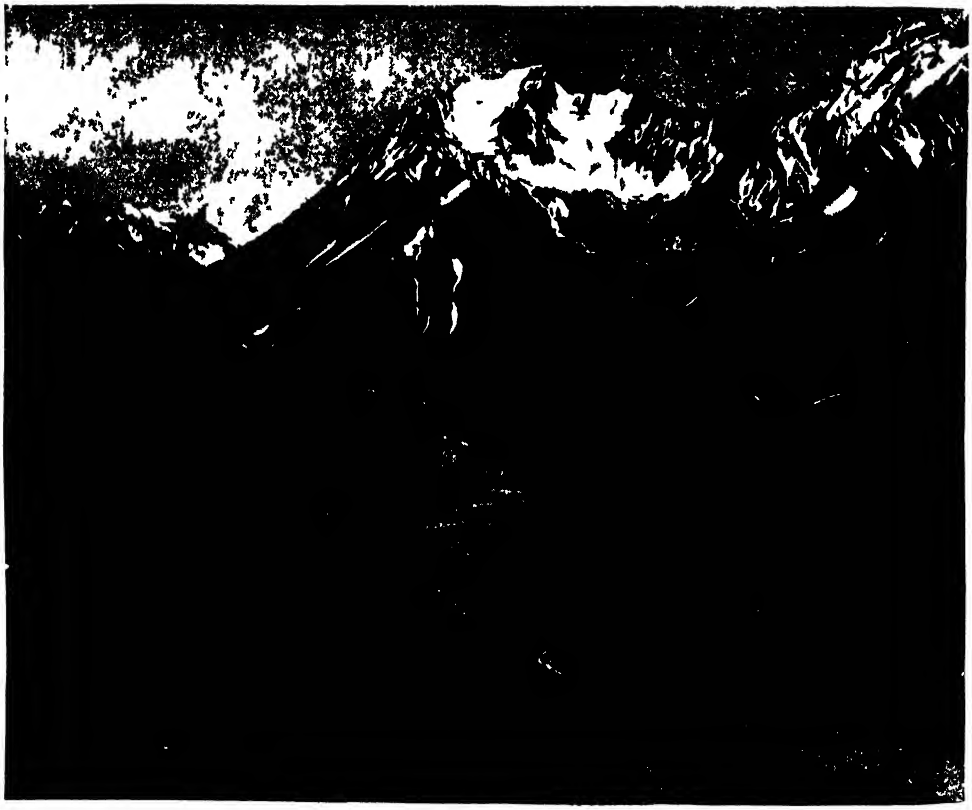


A VIEW OF THE HAMLET OF ST. CHRISTOPHE-EN OISANS ABOVE THE VENÉON VALLEY

This photograph and that on page 3309 are by Mr Donald McLeish

economy of Nature Firstly and chiefly they focus the mechanical energy of the water lifted into the sky by the heat-energy of the sun So far as the sun is concerned, the water-vapour would be spread uniformly through the atmosphere over the earth in a more or less indiscriminate way Were the earth flat, the rain would be much more equally distributed, there would not be 500 inches at Cherrapunji and 3 inches at Leh, but about the same rainfall in both places, and most of the variations that at present exist in the geographical distribution of rain would be light a city, or grind corn, or husk cotton seeds, or synthesise nitrates

As we have already indicated, mountains gather and give rain in two ways In the first place, any warm, moist wind blowing against a cold mountain summit is condensed as rain, in the second place, any warm, moist wind blowing against the base of a mountain is necessarily forced and deflected upwards into the rarer atmosphere In the rarer atmosphere the warm, moist air expands, and since expansion as we know means cooling the air is cooled, and deposits its load of moisture as rain. Not only



THE PASS IN THE ANDES IN TUNGURAGUA ECUADOR SHOWING THE SOURCE OF THE AMAZON

abolished Where the hills and seas now are the rainfall would be less where the plains now are, the rainfall would be more Further, a great part of the land surface would be converted into marsh-land and bog-land, for owing to lack of declivity drainage would be bad It is the mountains that focus the rainfall, it is the mountains that concentrate it into certain down-hill channels, and thus give it a maximum of mechanical power. The rain from the sky cannot turn a mill wheel, but the rain concentrated in a mountain torrent can does the cold mountain cool the air then but by directing its course upwards and compelling its expansion it forces the air to cool itself The tremendous rainfall at Cherrapunji is due not only to the contact of the warm, moist monsoon with the cooler hill-tops, but also to the fact that the monsoon is forced upwards by the Khasia Hills

Almost all the rainy places of the world from Portree and Shap to Mahabaleshwar, are places amongst the mountains, and most of the arid places of the earth are flat plains and when we compare the rainfalls of the

West and East Coasts of Britain we see the different effects of a warm, wet wind on mountains, and a dry wind on low lands. Compare, for instance, the rainfall of Margate with the rainfall of Devon, the rainfall of Scarborough or Cromer with the rainfall of Borrowdale or Fort William. The importance of this concentration and differentiation of rainfall is evident at once from a climatic, an agricultural, and a commercial standpoint. Did Nature not make rivers for us, we should have to turn to, like the fabled Martians, and make canals, or we should have to construct colossal systems of aqueducts. We must have our water supply mobile for many reasons, and, if it is to be a source of power, we must have it concentrated in rivers and waterfalls. It is true that the Amazon, the greatest river in the world, has in most of its course a gradient of only a few inches in the mile, but still its source is thousands of feet higher than its debouchement, and it is fed by the snowy summits of the Andes.

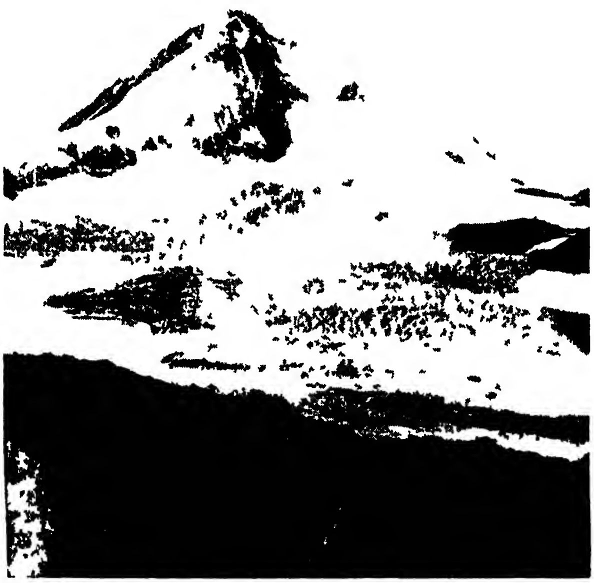
It is difficult to realise the amount of energy a mountain can gather simply by collecting rain. The amount of sun-heat required to evaporate sufficient water to cover one square mile to the depth of one inch is equal to the amount of heat produced by the combustion of five thousand tons of coal. The equivalent, again, in mechanical energy of this amount of heat would be sufficient to raise ten million tons to the height of one mile. It is immense solar energy of this sort that mountains seize and concentrate and utilise—energy that otherwise would be dissipated and, in great measure, wasted.

But mountains do more than seize and concentrate this hydraulic equivalent of solar energy; they also sometimes hoard and bank it. All these white summits of the Alps, the Himalayas, and Andes represent an enormous reserve capital of mechanical and chemical power. In winter the balance increases; in summer it diminishes, and the general result is a banking of energy at certain points, with a redistribution of it at certain times, both in the form of rivers of water and in the form of rivers of ice, but through both forms to the general advantage of the lowland world.

A DISTANT VIEW OF THE HIMALAYAS SHOWING MOUNT KUNCHINJINGA

Were it not for the Alps, the Po, the Rhône, the Rhine, and the Danube would be mere brooks in summer. "But for those barren fields of ice," writes Bonney, "high up among the silent crags (of the Alps), the seeming home of winter and death, these great arteries of life would every summer dwindle down to paltry streams feebly wandering over stone-strewn beds. Stand, for example, on some mountain spur and look down on the Lombardy plain, all one rich carpet of wheat and maize, of rice and vine; the life of these myriad threads of green and gold is fed from these icy peaks which stand out against the northern sky in such strange and solemn contrast. As it is with the Po, so is it with the Rhine and the Rhone, both of which issue from the Alps as broad swelling streams; so too with the Danube, which, although it does not rise in the Alps, yet receives from the Inn and the Drave almost all the drainage of the eastern districts."

But mountains do not always keep their reserve of water in cold storage; they also hold it in mountain marshes and peat beds and bogs. The amount of water so kept in reserve and economically and slowly expanded by a process of gradual drainage may be very great. Some flat mountains in times of rain are simply colossal sponges.



MOUNT HOOD, CASCADE RANGE, OREGON

Mountains, then, as makers and conservators of water force, play a most important part in Nature; they are in a sense at once the mainspring and the controlling lever of the greater part of the water-energy of the world. Very beautifully does Ruskin describe this function of the mountains. "Every fountain and river, from the inch-deep streamlet that crosses the village lane in trembling clearness to the massy and silent march of the everlasting multitude of waters in Amazon or Ganges, owe their play and purity and power to the ordained elevation of the earth.

"Gentle or steep, extended or abrupt, some determined slope of the earth's surface is of course necessary before any wave can so much as overtake one sedge in its pilgrimage; and how seldom do we enough consider, as we walk beside the margins of our pleasant brooks, how beautiful and wonderful is that ordinance of which every blade of grass that waves in their clear waters is a perpetual sign—that the dew and rain fallen on the face of the earth shall find no resting-place; shall find, on the contrary, fixed channels traced for them from the ravines of the central crests down which they roar in sudden ranks of foam to the dark hollows beneath the banks of lowland pasture, round which they circle slowly among the stems and beneath the leaves of the lilies; paths prepared for them by which, at some appointed rate of journey, they must evermore descend, sometimes slow and sometimes swift, but never pausing; the daily portion of the earth they have to glide over marked for them at each successive sunrise, the place which has known them knowing them no more, and the gateways of guarding mountains opened for them in cleft and chasm, none letting them in their pilgrimage; and from afar off the great heart of the sea calling them to itself. 'Deep calleth unto deep.'"

But the mountains can make rivers only at the expense of their own substance. Much of the great energy they render available goes to the destruction of themselves. Every brook brawling down the mountain takes part of the mountain with it. No matter how hard and durable the rock may

be, it is eaten away piecemeal by the power of the falling water.

> And surely the mountain fadeth away,
> And the rock is removed out of its place.
> The waters wear away the stones;
> The overflowings thereof wash away the dust of the earth.

Yet this destruction of the mountain is the salvation of the world as the habitation of living things; the débris of the rocks is the food of all the forests and gardens and meadows of the world. The rivers and glaciers wear down the mountains to make soil for the roses and cabbages. The most fertile lands in the world—the delta of the Nile, the plains of Mesopotamia—are made of the wear and tear of mountains brought down by great rivers.

Mountains, then, concentrate and apportion rain and make soil. Further, they promote the circulation of air, through the difference of temperatures at their bases and summits, and the rapid changes of temperature to which their peaks are subject. During a sunny day the top of a mountain is more heated than the plain below, and hence during the day there is an ascending current of cooler air from the plain to the mountains. At night, again, the hill top cools more rapidly than the plain, and so there is a descending current of cool air from the hill-top to the plain. This alternation in the direction of the wind is seen very well at Maloja, in Switzerland, which is situated on a high Alpine plateau above the plains of Italy. The strong winds produced in this way very much mar the winter climate of Maloja, which would otherwise be superb. The mistral so much dreaded on the Riviera is a torrent of cold air pouring down from the summits of the Cevennes and Maritime Alps. The bora of the Adriatic, and the tramontana negra or black norther of Greece, the "Majorcan carpenter," the black bise of Algeria, have similar origin. In the Himalayas the up-draught is very marked, and blows from 9 a.m. to 9 p.m. It is rather interesting to notice how even unscientific men have discovered this regular alternation. The hunter will build his fire below his tent at night, and above his tent in the morning, so that the smoke of the fire may blow away from the tent; and in certain valleys the inhabitants build their huts and houses on raised ground, to be above the river of cold air which flows down the mountains on winter nights.

IN THE ROCKIES OF WESTERN CANADA—THE THREE SISTERS

All these functions, then, in the economy of Nature mountains play; and in addition they form natural barriers between nations, and between flora and fauna—barriers which have great historical and evolutionary, as well as panoramic, significance.

THE SHADOW THAT FALLS ON THE SUNRISE OF LIFE—AFTER THE PAINTING BY JOHN BURR

THE CHILD'S LURKING FOE

The New Knowledge About the Beginnings of Consumption, Its Detection and Cure

RAIDING TUBERCULOSIS IN ITS HAUNTS

In the last chapter of this section we reviewed the chief facts of the existence of the enemy of man which we call the tubercle bacillus. We saw something of its distribution in nature; observed the fact of our ignorance regarding its possible evolution, at any time, from a merely saprophytic bacillus; came to the conclusion that our problem is also the problem of the bovine species, which cannot be solved for us unless at the same time we solve it for them, and ended with the opinion that, whatever be the facts of variation in natural, genetic, inherited susceptibility to the attacks of this parasite, there are also other factors, of unquestionable importance, with which it is our bounden duty to deal.

The observations of our own Royal Commission on the infection of human beings by the bovine form of the tubercle bacillus are the most recent contribution to the subject, but they only confirm what had long been assumed. If the student of tuberculosis were asked what was the most important new fact discovered regarding the disease in the present century, he would certainly name our new knowledge of its existence *in childhood*. On this matter we have hitherto entirely erred. It is a foremost fact, because the problem of conquering the disease really turns upon it: and no writer on the subject is doing his duty who does not insist upon this, the most important and most neglected fact of the disease.

Generally speaking, children are more susceptible than adults to infection. They suffer and recover, and are thereafter more or less immune, as in the case of measles or chicken-pox. Those infectious diseases which we do not associate especially with childhood are to be looked upon as exceptions. Sometimes the exception proves the rule, as in the case of small-pox, which is not now thought of as a disease of infancy and the years which succeed it, but was so before the introduction of vaccination, and is so still in an unvaccinated population. Tuberculosis has always been looked upon as a real exception. Fifteen years ago, and less, the universal teaching in medical schools was that this is a disease of early maturity especially, that it attacks the worker in his twenties, and is the characteristic disease of that period. Expectation and analogy would suggest the great unlikelihood of an infection being better resisted by children than by young adults. That is just the reverse of our experience in so many other cases. And now the real facts have come to light.

This is commonly a very chronic disease. It often runs a course of many years, and only during the latter part of its course can it be readily detected. The tubercle bacillus alone makes very slow ravages. The downward progress of the case is only apparent, very often, when other parasites join the tubercle bacillus, and the patient becomes the victim of a mixture of infections. Hence it is that the earlier stages of the disease have been until lately almost unrecognised. In early adult life, under the strain of hard and confined work, or in association with child-bearing, the patient has come to the doctor with symptoms, and it is presumed that the infection is as recent as they are. That is far from the fact. Often doctors have observed certain types of physique, shape of chest, fineness of hair, and so forth, which were supposed to be typical of the kind of person specially liable to be attacked. It has not occurred to us that possibly these features may be the result of a long, slow, insidious process, which was gradually wearing down, and producing these apparent marks of natural delicacy in, the patient's physique.

It gradually began to be reported that,

on really careful inquiry, signs of early tuberculosis could be detected not infrequently in children; and then it was seen that a new examination of the child population was necessary from this point of view, with the aid of the most delicate and exact methods of diagnosis. The old days of diagnosing tuberculosis by means of tapping the chest and listening to the sounds produced within it are gone for ever from the realm of science. Such methods have their constant uses in the observation of a case, but as means of saying whether the tubercle bacillus is actually present they are utterly crude, and the information they can afford is tragically belated. A stage in advance of that depended upon the identification of the tubercle bacillus in the sputum, or expectoration, of the patient. That method was of immense service, and always will be so, but we must look upon it as entirely superseded by modern standards of diagnosis. Our business in this disease, from the national point of view, is to identify *every case* at the earliest possible stage, and to have *no untreated case* in the community.

The Need for Recognising the Presence of the Tubercle Bacillus at the Earliest Moment

Once we see that the disease is an infection, and think of it as we would think of plague or cholera, we recognise the necessity of realising this ideal. We therefore require to employ the most delicate methods possible for identifying the presence of the bacillus, even long before symptoms appear, and not least before the bacillus begins to be discharged in millions from the body of its host, for that means that all our work will have to be indefinitely continued. We want the cases which show no symptoms, because then we can do more for them than at any later stage; and we want the cases from which no tubercle bacilli can be obtained, so that such patients shall either be cured and never discharge bacilli, or so that, if that discharge must happen, others shall be protected.

Fortunately, the advance of science has made possible what we need. The two methods must only briefly be referred to before we proceed to note the results they have attained, and to demand that they shall be applied on a national scale, at any rate as soon as their utility and safety are beyond question. The first method is the use of the Röntgen rays by the newest apparatus. According to those who have had opportunities of judging, the shadows of thickening round the air-vessels of the lungs, due to the tubercle bacillus, can now be positively detected at stages when no certain symptoms appear, when the ordinary methods of physical examination reveal nothing, and when no tubercle bacilli are being expectorated. Secondly, there are the subtle methods of diagnosis which depend upon the same principle as the "tuberculin test" for suspected cattle.

The distinguished French student Professor Calmette, of Lille, and others, have employed means whereby the introduction of a small quantity of a harmless product of the tubercle bacillus will reveal whether or not the tested individual is infected.

Startling Revelations as to the Number of Infected Children

The results of careful examination of children on such lines, in many parts of the world, have been extremely striking, and place an entirely new aspect upon the practical problem of tuberculosis. The percentage of children found to be infected has steadily risen as methods have improved, and a large series of *post-mortem* examinations have established the facts beyond question. The result is to show that tuberculosis is primarily a disease of childhood. It cannot be doubted that at least one-half—and in some Continental towns, such as Vienna, a much higher proportion of the inhabitants of large towns have been infected by the tubercle bacillus *in childhood*. Probably the essential infection habitually occurs in childhood. Some of those infected die as children. Some only begin to suffer obviously in early adult life, while the greater number conquer the bacillus, and live, to die of something else. This result is, of course, of great interest from the purely scientific standpoint. It requires prolonged further study before we can define the source of the infection.

A Change of Plans Necessitated by the Frequency of Infection in Childhood

We cannot yet say what proportion of these almost innumerable children, from whom the future victims of consumption will be selected, have been infected by the bovine form of the bacillus from cows' milk, nor what proportion have been infected by the inhalation of the "human" form of the bacillus from "open" cases of consumption

But the great fact for practice is the simple one that if we are to conquer this disease we must begin with the tuberculous child. Even to the present writer, an habitual student, such a phrase still reads strangely, so unfamiliar are we with the idea of the infected child as the predecessor of the consumptive adult. We have been assuming,

for many years, that this is a disease of adult life, and that the consumptive child is a rarity that may be ignored. We now learn that, though the actively consumptive child may be a rarity -not so rare, alas! --the infected child is probably at least as common as the uninfected child. And the consequence is that we must reconsider our national and concerted efforts for the conquest of this disease.

Notification of the Presence of the Disease the First Step

Already we have discussed the question of the cow and its milk. That is cardinal, and we remind ourselves of it. But now we are faced with the problem of the human population infected with tuberculosis. These patients, children and adults, are important in themselves, for there must be at least half a million of them showing symptoms in this country at any time, and a far larger number in whom no symptoms yet appear; and they are also important, because some of them are actually spreading the bacillus, for the infection of their neighbours, and because the rest may begin to do so at some future date unless we somehow interfere. Given these circumstances, what is the rational course to pursue?

The first, beyond a doubt, is the notification of the disease. Any number of trifles that matter not at all, or scarcely at all, are now notifiable. When a new, rare malady, like epidemic cerebro-spinal meningitis, makes its appearance, someone gives it the terse name of "spotted fever," the papers discuss it, and when it is made notifiable everyone approves and heaves a sigh of relief. Tuberculosis of the lungs kills thousands for every one whom "spotted fever" attacks; and its infectious character is proved. Plainly it must be notified.

The Extension of Notification to All Forms of the Disease

In some parts of the world this has been the rule for a long time, notably in New York, where very great success has attended the policy. Thanks to the admirable work lately done by the medical department of the Local Government Board, and thanks also to the education of public opinion by a few devoted persons, it was possible to make tuberculosis of the lungs notifiable in England and Wales from the first day of the present year. Until that date, Scotland had been far in advance of England in this respect; and no doubt the Local Government Board for Scotland will soon follow suit, especially in relation to the tuberculosis provisions of the Insurance Act.

But the time has now come when we must make a further step; and all the foregoing discussion has been worth very little if the reader is not already convinced of the scientific grounds upon which we demand it. It is simply that *all tuberculosis* must be made notifiable. The existing order, in England and Wales, which are at the moment the most advanced parts of the country in this respect, deals only with pulmonary tuberculosis. But our view of the disease as a whole has shown us that this cannot be adequate. The discovery of the tubercle bacillus has given us the true conception of all forms of tuberculosis as really one, and we see that the problem is to deal with that bacillus, irrelevantly of whether it happens to be attacking the lungs, or the glands in the neck (whence it may very soon reach the lungs), or any other part of the body.

The ideal, as Dr. R. W. Philip, the famous founder of the Tuberculosis Dispensary, asserted long ago, is that every case of the disease in the community shall be known and treated. Therefore every case must be notified.

The Non-Infectious Nature of Some Forms of Tuberculosis

Some students of the subject will not be surprised if, before very long, public and professional and administrative opinion in Scotland, which has long led in this respect, and taken the first steps, express themselves in an order making all forms of tuberculosis notifiable in that country. To this every part of the United Kingdom and every civilised country in the world will surely come.

If we be asked why pulmonary consumption should be notified, the first and most urgent reply is that the disease is infectious, and we want to protect other people, just as in the case of other infections. There are many other reasons, quite sufficient in themselves, as that, if a certain block of buildings is a plague-spot, and infects all its inhabitants, or nearly all, in succession, we want to identify it, and either pull it down or disinfect it, but certainly the primary reason for the notification of pulmonary consumption is that this is liable to be the infectious form of the disease. Now, the case of consumption, or tuberculosis, elsewhere than in the lungs, is rather different. A tuberculous knee-joint is not infectious, because there is usually no outlet for the bacilli; and even if there be, the risk of infection of others is very small. The grounds, therefore, on which the modern

student of national life and health demands the notification of all forms of tuberculosis must be stated.

First, every case whatsoever should be notified, in order that, if necessary, steps may be taken to ensure its proper treatment. This may or may not rank as charity; it is certainly politics. The case must be treated because of what it may mean for others. Every case of tuberculosis, of whatever form, may some day develop into a case of pulmonary tuberculosis by spreading to the lungs. It may be a case of a joint, perhaps, affected by the bovine form of the bacillus, but the Royal Commission found that the bovine form of the bacillus may be found in the lungs in cases of pulmonary tuberculosis. Therefore notification applies here, as in the case of pulmonary tuberculosis; and it is much more likely than in that case to be effective before anyone else has yet been infected.

Second, as the reader of the last chapter will see at once, we must have all forms of tuberculosis notified, because we must discover where and whence deadly milk is being supplied to the community. So long as we only notify pulmonary tuberculosis, which is mainly due to human infection, we are only dealing with half the problem.

The Varying Carefulness of Different Cities with Respect to Infection

We must find exactly where the disease is being planted in children from the cow, and we must then proceed to deal with the source of the infection. It is probable that, if all forms of tuberculosis were now notifiable, some startling and significant facts would at once come to light. Many towns are particular as regards their milk supply, while others have no effective by-laws. The consequence is that, for instance, milk which Manchester would not look at is sent to London. We must ascertain what is the distribution of the forms of tuberculosis due to infection by the bovine bacillus, and we must then act accordingly, with energy and promptitude.

It is therefore here laid down that the first step towards a really national, rational, and efficient campaign against tuberculosis is the compulsory notification of all forms of this disease. In logic and in practice this should precede the expenditure of money upon any measures for cure; it involves no cost worth naming, nor has it any other objection. It only requires a sufficient extension of "popular science" in order that its reasonableness may be seen, and then it will be done. Administrators wait only for that, and then they will do what they well know to be necessary.

The discovery that this widespread infection usually occurs in childhood has largely coincided in time with the advent of medical inspection in the schools of this country. That is, of course, indispensable to our purpose. In large measure it will mean that the cases are identified at a period sufficiently early for the interests of the child and of the community, before symptoms of any noticeable kind have appeared.

Continuous Inspection of Children by the Latest Methods Needed

However, if this problem is to be dealt with as it requires, the standard of inspection will have to be raised. Comparison of the results obtained by the older and the newer methods shows that only the latter will really avail for our purpose.

Not less important is the fact that medical inspection only begins at the school age. In another section of this work reference has been made to the special needs, from the eugenic point of view, of what was there called the "home child." Our recent discovery of the age of infection in tuberculosis compels us to consider the "home child" again from the point of view of tuberculosis. Pathology has established the fact that, with exceptions almost infinitely rare, children are born free from infection. During something like the first year of life they will probably remain free from the risk of infection by the bovine bacillus. It is the period between infancy and the school age that needs attention. Here we are not concerned with the development of the individual human being during those years.

The Advent of Disease Through the Unsupervised "Home Child"

We are simply concerned with the fact that the infection of tuberculosis, through cows' milk especially, now probably occurs for the first time, and that no existing agency, national or voluntary, deals with the need. No definite knowledge of the state of our young population before school age exists. Between infancy and the school age the State ignores its children, though it is about to pay for inspection at the school age and for illness at the industrial age. It is very absurd, but we do it. Fortunately, a national society is now in process of formation, which is to deal largely with the "home child" and its needs: and hygienists are coming to see that this is a period of life, inevitable for

every individual, which they have neglected hitherto. An important discussion on this subject was opened most usefully at a recent Health Congress at York.

Allusion has already been made to Switzerland and the anti-tuberculosis campaign in that great little country. Long a pioneer in education, Switzerland recognises the needs of the whole child, and will almost surely be the first country in the world to stamp out this disease. The Swiss definitely recognise that in order to do so they must begin with the child, whom we here have scarcely heard of in connection with consumption. Already they have seen the duty of removing uninfected children from homes where the parents are the victims of "open" tuberculosis. Now they have substituted "holiday camps" or "holiday colonies" for school children in the summer months, generally in some mountain district, at heights of about four or five thousand feet.

How the Swiss Conduct their Anti-Tuberculosis Campaign

A recent report, referring to the fact that constantly more children than ever are being dealt with in association with the anti-tuberculosis campaign, proceeds as follows. "In the Jura, above the Lake of Biel, there are some of these holiday colonies nearly every mile. Holiday colonies and camps, of course, exist in other districts of Switzerland, but the Jura is one of the favourite places for them, one reason doubtless being that so few foreign tourists go there. The children, who sleep in tents, spend almost the whole time out of doors. Their parents pay from 8d. to 1s. 8d. a day for them. The holiday colonies are of two kinds one for ordinarily healthy children, the other for delicate children. In the former, some of the older children do something to help with making beds and preparing vegetables for dinner. The food is simple, wholesome, and abundant—soup, meat, and vegetables for dinner, for instance."

In this country also we are making slow progress. Our first school for tuberculous children was established in Paddington rather more than a year ago, in association with the tuberculosis dispensary, of which Princess Louise is patron. At her recent visit to the school, Dr. Philip said that "if we get hold of the tuberculous seedlings of the population, within a generation half the tuberculosis in the country will have ceased to be." By no means too sanguine an estimate. When the school was first opened - it is, of course, an open-air school—there was great difficulty in persuading parents to allow their children to attend. Now, however, all that has changed, and the parents are enthusiastic. Such schools are an imperative necessity in the light of our new knowledge. We see now that the ordinary school is simply encouraging tuberculosis in a large proportion of the scholars, and favouring its spread. Medical inspection identifies the affected children; and if they are to be schooled at all they must be schooled separately under proper conditions.

The Spread of the Anti-Tuberculosis Movement from Edinburgh

But, as we have seen, medical inspection cannot discover the very young children. It is clear that more is required, and that more is furnished by what Dr. R. W. Philip calls the Tuberculosis Dispensary. It was in 1887 that Dr. Philip founded the first of these institutions in Edinburgh; and the present writer is fortunate in having been a pupil of this pioneer, who has at last achieved world-wide fame, and whose ideas are being applied everywhere. The dispensary is the central structure of what is now generally known as the Edinburgh Anti-Tuberculosis Scheme. Its importance is realised only by experts and practical workers, and has been greatly ignored by politicians and others in relation to the present national campaign. The cry has all been for sanatoria; but we know that the first necessity is for the dispensary in every town, whence patients will be sent either to the hospital for advanced cases, or to the sanatorium and thence to its associated colonies. That is the least of the functions of the dispensary.

The Arrest of Early Cases, and the Spread of Knowledge by Dispensaries

Its cardinal feature is that from it proceed emissaries to the home of every patient, in order to find the early "contact cases," which have already been infected. These will very largely be children, and at once is the time to deal with them. The dispensary thus gives us, cheaply, directly, and simply, what nothing else can— a means of access to the early cases wherever they exist, and at whatever age.

Until the end of the nineteenth century there was only the original dispensary in existence. Today there are several hundreds in this country, France, Germany, the United States of America, and elsewhere. The Hampstead Borough Council has decided to establish what will be the first municipal dispensary in London. After a quarter of a century we see the

whole world accepting the Edinburgh system, which has been thus authoritatively defined. "The fundamental principle of the scheme is that, not content with treating the individual patient who presents himself, the disease should be sought out in its haunts; in other words, to use a military axiom, the war should be carried into the enemy's country. After all, only a fraction of the number of persons affected apply for treatment, and it is by following up these cases to their own houses that Dr. Philip's system grasps the problem at its very root." And now we are beginning to see great results from a humble scheme which was established in memory of Queen Victoria's jubilee, and has already brought jubilee to scores of thousands.

In the scheme of operations here set forth, the sanatorium is not primary. It has its due place, and an essential one. The idea, sedulously fostered of late, that sanatoria are an obsolete invention, has no basis. On the contrary, we see important functions for sanatoria which cannot otherwise be discharged, as will be shown shortly.

Sanatoria Not for Primary but Secondary Treatment of Tuberculosis

Meanwhile, we are to observe that sanatoria are not primary but secondary in any rational and co-ordinated scheme of war against tuberculosis. In the proposals of the Insurance Act, as they were originally formulated and discussed and understood by those who finally made them into law, the sanatorium occupied a foremost place, and the dispensary was not even mentioned. Probably that was as well, in obtaining the consent of Parliamentary and public opinion to the expenditure of large sums of money on a basis of compulsory contributions. It was no doubt necessary to offer a definite *quid pro quo*, a substantial benefit for the ill contributors. We see, however, from the scientific standpoint, that more is required; and fortunately knowledge and quiet judgment were available.

The Insurance Act is so worded that sanatoria or other institutions may be provided under it. The statutory phraseology is such as to admit the tuberculosis dispensary; and the most urgent need of the moment is popular education as to the simple, unquestioned, scientific grounds on which we ask that first things shall be done first, and that dispensaries shall be set up, above all for the discovery of early cases, in the interests of the community at large and the "prevention of sickness," as set forth in the preamble of the Act.

From the scientific point of view, an infectious disease requires to be looked at as a whole. A scheme of national insurance, proceeding on an industrial basis, comprises certain selected groups of people, on the ground that they are wage-earners, many men, some women, no school children, and none before the school age. This has its own advantages, especially in reference to insurance against lack of wages; and those do not concern us here. But from the point of view of biological medicine, which is asked to undertake the extirpation of an infection, such a scheme is bound to be very imperfect and even absurd.

The Necessity for a Universal Treatment of a Disease that is Infectious

If the insured alone were liable to the infection, all would be well; but the fact is that the infection may attack, and be spread by, men, women, and children, quite irrespectively of the fact that they are workers, or have such and such an income. If this were Oriental plague, the "Black Death," that we were attacking, instead of the White Plague, every one would see what the man of science sees that it is wildly absurd and wasteful to pick and choose, saying that we will treat this case because the patient is a wage-earner between sixteen and seventy, and not the next, because the patient is only fifteen, or merely slaves from morning to night in her own house. These distinctions mean nothing to national hygiene, and the absurdity and irrelevance of them will require to be recognised by everybody.

The Sanatorium a Confession and Requirement of Failure

In an Act of insurance against lack of wages due to sickness, a brave and valuable attempt has been made to initiate a national campaign against a national enemy. Everyone approves of the principle. It is now for us to learn that that campaign must ignore all the economic distinctions set up in the Act, and must tackle tuberculosis wherever it is found, in man or cow, if it is to succeed. So-and-so may not come under the Act, but if he is liable to come under the acts of the tubercle bacillus he concerns us all, not least the insured, whom, owing to our neglect of him, he will shortly begin to infect. A point so simple and fundamental, ignored in public discussion of the Act hitherto, except by the present pen, will surely be accepted by the reader on the scientific grounds already laid down.

The first necessity, we saw, was universal notification. The second was the dispensary,

the two being, indeed, companions. Next comes the sanatorium, *the confession and requirement of failure.* Let those words be weighed, for few of us realise their meaning yet. If we did our duty when and as we should, there would be no need of sanatoria; and, indeed, it is to be expected that, in the course of years to come, the sanatoria about to be built will be found superfluous, and will have to find other uses—of which there are plenty. Meanwhile, because we fail in our first lines of defence against the tubercle bacillus, we require sanatoria, hospitals for the wounded, who should not have been wounded. If sanatoria cured all their patients, they would still be symptoms and consequences of failure an assertion which requires a decade of reiteration on every hand, and will receive it. As it is, sanatoria are necessary, and they cure some of their patients.

The Exaggeration of the Good Results of Sanatoria

The measure of success they attain, even under fortunate conditions, has, as a rule, been shockingly exaggerated. Patients do not recover to the extent of 90 per cent., as used to be asserted. Patients who were in sanatoria ten years ago are not so easy to find. If sanatoria achieve even 20 per cent. of absolute cures, among the patients who will be sent to them under the Insurance Act, many impartial students of the subject will be agreeably surprised. Not for a moment do we assert that any better chance of salvation offers itself at present, or that this should not be made available generally; but we shall be wiser in the long run, and happier, if we conform our expectations to what experience teaches.

The patients who have been saved by sanatoria hitherto are those, belonging to the type already defined, whose illness has been due to external causes predominantly, and who leave the sanatorium *not* to return to those external conditions. They practically spend the rest of their lives under something like sanatorium conditions. We have to ask ourselves how far such a requirement can be met in the campaign on which we have embarked; and the answer is fearfully disconcerting.

But the sanatorium is invaluable as a means of isolating the infection. Here, again, is the stern teaching of science, which may be little suitable for popular and political purposes, but we are bound to assert it here. Probably every case that goes to a sanatorium averts the infection from someone at home, who would have been sleeping in the same bedroom, perhaps, or from someone working in the same office or shop. The sanatorium performs, with the utmost kindness and the best prospect of recovery for the individual, the function which the lazar-house performed in the Middle Ages, without any hope of recovery for the unfortunate leper.

The Use of Sanatoria to Confine Infection that should not have Occurred

This is what the public must learn. It is the real scientific ground on which the sanatorium bases its chief claim; and the quarrel over percentages of cures achieved by it is happily irrelevant. It confines the infection which should never have occurred. Therefore, let those who deplore the cost of sanatoria, and their small percentage of permanent cures, set to work to establish the conditions which will make sanatoria superfluous. Meanwhile, they are most valuable; and the leading epidemiologist in this country, Dr. Arthur Newsholme, of the Local Government Board, has adduced formidable evidence, in his book, "The Prevention of Tuberculosis," to show that the steadily increasing "institutional segregation" of cases in this country, during the past seventy years or so, has been the dominant factor in the decline of the disease during that period. The concurrent decline of alcoholism has doubtless been more than a coincidence, and the opinion of the International Congress on Tuberculosis has already been referred to in this work.

The Raiding of the Disease when it First Appears

We have now defined and briefly discussed the main factors in this problem, from the standpoint of biology and the most recent knowledge. The fact has to be realised that treatment by "tuberculins," existing or still uninvented, and in sanatoria, however successful, is a symptom of failure. The disease must be raided in its haunts, and the earliest cases, which will also be, as a rule, the youngest cases, must be discovered. For this the dispensary is cardinal. The national campaign must deal with the whole community, not on any charitable or sentimental grounds, and without any depreciation of the contributory basis of the Insurance Act, but for purely biological grounds which are obvious. Sanatoria and special hospitals must isolate cases which would otherwise spread the disease, meanwhile curing as many of them as possible.

HOW THE FUNGUS FOE OF WHEAT SPREADS

THE TWO-CELLED STALKED SPORES OF WHEAT RUST BREAKING FROM THE WHEAT IN SPRING

THE SPRING SPORES OF WHEAT-RUST GERMINATING ON THE LEAF OF THE BARBERRY

These two pictures and that on page 3331 show three stages in the development of wheat rust or mildew. The top picture shows the wheat in section, with the clusters of two-celled stalked spores (basidiospores) breaking from it. These spores are developed in the spring from the resting or winter spores (teleutospores), and germinate on the leaves of barberry. The lower picture shows spring spores, blown from wheat to barberry leaves, germinating and producing excrescences, which burst out into little cups [illegible] orange-coloured spores, known as aecidiospores. In this section of the barberry leaf one cup is shown unopened and another [illegible] developed. These spores return to the wheat, where they produce the one-celled blight spores (uredospores) shown in the picture [illegible] page 3331. These reproduce their kind on the wheat very rapidly. As autumn draws near these one-celled spores give [illegible] to the two-celled teleutospores, which tide the fungus through the winter. A diagram on page 3330 sets out the three [illegible]

Photographs by Mr J J Ward

ENEMIES OF PLANT LIFE

Moulds that Form on Fruits and Bread; and Fungi, Smuts, Rusts, and Mildew that Attack Potatoes and Cereals

THE BEST WAYS OF WARDING OFF ATTACKS

First amongst the common diseases which attack plants and their products we may consider those due to species of fungi. Some of these are parasitic on both plants and insects, but most of them are saprophytes. We may take, as a type of a very common form of growth, the mould *Mucor mucedo*. It is universally distributed in the world, and grows with consummate ease at ordinary temperatures upon such substances as jam, damp bread, and other materials, especially such as are of a starchy or sugary nature. It is also found on fruits. This fungus exhibits very well the type of structure in many moulds, and by paying a moment's attention to it we may avoid the necessity of repetition.

Like others, it has its main mass made up of a mycelium, composed of a number of fine threads, or filaments. Under a magnifying glass they are seen to be ramifying in every direction, on the surface of the substance on which it is growing. Shooting upwards into the air from this mycelium are a number of vertical hyphæ, which swell out at their ends into a rounded body—the sporangium. Inside this again are many minute little dots, oval in shape. These are the endospores. Such is the simple and entire structure of this ubiquitous fungus.

So universal is its occurrence that practically all kinds of starchy and sugary foodstuffs and fruits have to be protected in some way from infection from it. It is for this reason that specially valuable fruits are commonly wrapped in tissue paper when packed for the market; and, moreover, since some of the mucors can only damage fruit that has been bruised or otherwise injured, there is an additional incentive for very careful handling. Fruit which is in any way bruised allows of the entrance of the spores of the mucors, and they rapidly grow and produce a condition of rottenness.

A very simple experiment, and one of considerable educative value, will convince the reader that it is no mere theoretical statement, but an easily demonstrated fact, to say that these moulds are everywhere. If a piece of bread be soaked in water and placed in some receptacle where it will remain undisturbed, a very few days will prove that it contained, or had come into contact with, the spores of probably more than one species of mould. Their appearance is marked by a familiar whitish or greenish growth. A minute portion of this now mouldy bread placed under a magnifying glass will, in all probability, reveal the existence of *Mucor mucedo*, the appearance being that shown in one of the illustrations on page 3327. The erect hyphæ, with the little knob at the end, are very characteristic.

The vexed question amongst housekeepers as to whether jam should be covered up when still hot, or left to cool, resolves itself into a simple matter of the knowledge of fungus life. The truth, of course, is that if the jam be covered while it is sufficiently hot to kill any of the spores on its surface, no mouldy growth can take place. An additional precaution, however, to be taken is that the material used to cover the jam must in itself be free from spores which might otherwise subsequently develop.

The condition known as "damping-off" in young plants and seedlings may well be taken as the introduction to the actual diseases of plants, because this, too, is due to another mould, or fungus—namely, *Pythium de baryanum*. Every amateur gardener, at some time or other, has had the disappointing experience of finding a large number of seedlings beginning to wither up and die in patches soon after emerging from the surface.

This takes place especially when the seed-bed or box has been placed in a dark or shaded spot and given a liberal supply of water—two conditions eminently suited for the growth of fungi. A very common instance of this damping off is to be seen in growing mustard and cress, where the plants are, of course, intended to grow thickly. It is first noticed that the seedling begins to bend over in a very typical way, and a close examination will at once reveal the fact that this collapse of the seedling is due to one part of the stem being somewhat shrivelled up. Once damping off starts amongst a crowded seed-bed, such as a box of mustard and cress, it is found to spread with great rapidity from a central point in all directions, and if it be allowed to run its own course we ultimately find that the whole mass of plants gradually die off and rot.

Areas of a whitish, mouldy appearance can be seen distinctly. If such a soil be utilised again for a similar or other crop, it will be found that this second crop will likewise become infected, and so on with any number of successive crops, so that the vital agent, the mould, evidently remains active in the soil for a long time.

To ascertain the actual state of affairs in seedlings which are damping off, all that is necessary is to examine one of these microscopically, when it will be found to be penetrated by the mycelium of the fungus above mentioned. At first the filaments of the fungus remain within the tissues of the seedling on which they are feeding, but presently it extends its growth outwards into the air, and by actual contact, because of the closeness with which the seedlings are growing to each other, transfers itself to all those in the neighbourhood. Then, as the seedlings begin to bend over, they entangle themselves with those nearest, and so spread the fungus.

VEGETABLE MOULD—PENICILLIUM GLAUCUM

If some of the hyphæ of this fungus be examined after some hours of growth, they will be observed to be producing the different reproductive organs which we have already described as being characteristic of fungi. Round, oval spores, or conidia, are found, and they quickly produce new filaments. Sporangia also grow, containing numbers of spores within them which, when the sporangium ruptures in water, as it does, also grow to maturity. Both these are asexually produced, but, in addition, sexual reproduction of ova takes place by the union of a female reproductive organ, or *oogonium*, with a male element, or *antheridium*. A small part of the latter is mingled with the ovum from the oogonium, and this after a period of some months produces a mycelium. These latter spores, produced sexually, contaminate ground for a considerable time, and being produced in enormous numbers, constitute a frequent source of infection.

The cause of this condition being known, it is not difficult to avoid the disease. The two main points to be considered are the amount of moisture present in the seed-bed and the closeness of the sowing of the seed. Hence the common instruction given with seeds to "sow thinly." Most people give a great deal too much water after sowing seeds. Allowance must be made, too, for the due penetration of plenty of air and light. In spite of all precautions, damping off will, however, sometimes occur, and then steps should be taken to eradicate the fungus from that particular mass of soil. The only satisfactory way to do this is to burn all the plants, with as much soil attached to their roots as can be pulled up with them. If the seedlings are in an open bed, the best plan is to have a bonfire on the spot, and turn over the soil to a considerable depth, so as to bury deeply any spores that may be left.

We now come to the consideration of some plant diseases which have an immensely important bearing on the food supply of the people, and so are of great economic importance. First and foremost amongst these we may consider what is usually termed the potato disease, though, as a matter of fact, several distinct conditions are referred to under this general title. One of these is generally termed *the* potato disease, an expression rather apt to convey the erroneous idea that this valuable plant suffers from no other disease, which is not the case. But the disease known by this general title, and sometimes also called *Late Blight*, is the one, unfortunately, to be found at times in all parts of the world where the potato is grown, including, of course, the British Isles, where the disease usually breaks out in July or August.

The first sign of the potato disease is observed on the leaves of the plant. They lose their brilliant green hue, and become mottled with patches of yellow, then they gradually assume a dark brown, and even black, aspect as the portion of the leaf affected dies. In a hot, dry summer, the patches on the leaves do not much increase, but should the weather be unfavourable—as, unfortunately, it all too often is in our climate—one leaf after another is seen to become affected, and the patches on the individual leaves get larger and larger. In severe attacks, not only the leaves but the stems become affected, and the unfortunate plant is quite obviously in a most unhealthy state, the haulm dying down and quickly assuming the character of a dark, wet mass of tissue with an evil smell.

If we examine one of the dead patches on a potato leaf thus affected, we find around the black spot a greyish-white portion, spoken of as mildew. This is extremely characteristic of the potato disease, and differentiates it from other conditions that attack the leaves of the potato, as well as from their natural decay. The importance of this disease of the leaf lies, of course, in the fact that the accumulation of starch and other food materials in the potato plant, as in other green plants, depends entirely upon the capacity of the leaves to manufacture these substances. The leaves are the life of the plant, so that if they become diseased before the full accumulation of food substances has taken place in the tubers, the latter will naturally be much smaller than they otherwise would be. The potato crop is thus diminished. In addition to this, however, in the most severe outbreaks, where the invasions extend actually to the stems as well as to the leaves, the tubers themselves are found to be imperfect, and exhibit brown patches under the skin.

FILAMENTS AND SPORE-HEADS OF MUCOR MUCEDO

The fungus which is responsible for this widespread potato disease, or blight, is known as the *Phytophthora infestans*. Its mycelium enters the actual substance of the leaf and grows therein, sending out in damp weather its branched hyphæ, which are seen to emerge through the stomata. As usual, they bear sporangia and conidia at their free ends, and these, in their turn, produce spores, which ultimately develop a new mycelium. It is by means of the different spores that the condition spreads from plant to plant, and, since these are produced as usual in infinite number, one can readily understand how the potato disease, once started, will affect a very large area. The slightest contact between growing plants is sufficient to transfer the fungus from the one to the other, whilst the spores are carried by the wind without the slightest difficulty.

It is not quite certain how much of the actual destruction of the tubers themselves

is due to the penetration into them of the fungus, because it is quite common to find that the leaves, and even the stems, may suffer somewhat seriously without any great damage being done to the tubers underground. Assuming, however, that the fungus does attack the tubers themselves, it may readily reach them either by direct continuity through the stem, or by means of the spores being carried down through the earth by the percolation of water through the soil. From the fact that the disease may break out year after year, it is obvious that, in some way or other, the fungus can survive the winter months. During this time it must, of course, be saprophytic, and probably lives in the tubers during that time, making fresh growth when these are planted in the succeeding year. It is only right to point out, however, that opinions on this matter are very divergent.

In addition to the potato, this fungus also attacks the tomato leaves, those of petunias, and some other members of the same family.

Experiment has shown that some varieties of potatoes are much less susceptible to infection than are others; and the advice to be given, therefore, is to ascertain what potatoes escape the disease in any given season when it is prevalent, and to use only these in such districts as it occurs. In order to kill as much of the fungus as possible, all the leaves and stems of potatoes suffering from it should be burned. It need hardly be pointed out that no tubers should be kept from a diseased crop for seed. Care also is required in the use of manures, those of the nitrogenous type apparently favouring the growth of the fungus more than those of the potash salts and phosphates. Adequate drainage to prevent undue moisture of the soil must also be carried out.

As regards actual applications when the disease has started, the well-known Bordeaux mixture is perhaps the most effective. It is composed of copper sulphate (12 lb.), quicklime (8 lb.), and water (100 gallons). These quantities are sometimes varied. The copper sulphate is dissolved in hot water, to which 60 or 70 gallons of cold water is added when the sulphate is perfectly dissolved. Then the quicklime, freshly prepared, when perfectly cold, is filtered into the vessel that contains the copper sulphate, and as much water is added as is required.

This mixture is not of any great service once the disease has broken out. It is used as a preventive where, owing to the prevalence of the condition in the neighbourhood or the dampness of the season, it is feared that the crop may be attacked. It acts, in all probability, by preventing the growth of the spores, and it may be repeated at intervals of two or three weeks. It also stimulates the growth of the plant itself, as is evidenced by the improved condition of the leaves.

POTATO-LEAF RUST CAUSED BY UROMYCES IN UREDOSPORE STAGE

1. Under side of affected potato foliage-leaf; 2. Upper side of affected potato foliage-leaf; 3. Healthy potato foliage-leaf.

Early blight is a condition affecting the leaf of the potato common only in America, and thought by some to be less rare in this country than is really supposed. It is caused by another fungus, *Macrosporium solani*, which produces large, spindle-shaped conidia on its hyphæ. These grow into the leaves and cause brown patches, which grow more slowly than those of the potato disease, and are not so dark in colour. The tubers are not affected. The Bordeaux mixture, previously mentioned, is applicable to this condition also.

The conditions hitherto described have been those which affect the leaves either entirely or, at any rate, primarily. But there are other diseases of the potato whose effects are obvious in its most valuable product—namely, the tubers. These latter are said to suffer from wet-rot, dry-rot, and scab; and a word or two must be said of each.

Wet-rot occurs principally in hot seasons with considerable rainfall. It shows itself in the shape of a number of dead patches just under the skin of the potato, the whole tuber soon becoming brown in colour, watery in consistence, and ultimately quite slimy. We are probably dealing here with what the bacteriologist terms a mixed infection—that is to say, a diseased condition produced by more than one species of living agent. There is probably a primary invasion of the tuber by various kinds of bacteria, which devitalise the tissues and so render them susceptible to the further attacks of saphrophytic fungi; or, conversely, the tubers may be attacked by fungi which injure the potato and allow of the entrance of bacteria. Both kinds of infecting agents are doubtless concerned.

Dry-rot is usually found in potatoes which have been stored up. Here, instead of the potato becoming slimy and wet, it loses its moisture, and shrinks into a wrinkled, chalky mass. The causal agent, in many cases, is the fungus known as *Fusarium solani,* which is quite obvious on the outside of the withered tubers in the shape of white, mouldly spots. It enters the tuber by means of its hyphæ, consumes the protoplasm, but leaves the starch which forms the mass of the dried-up potato.

Scab on potato is an expression used to indicate various appearances on the surface of the tubers produced by parasitic organisms. In order to prevent potatoes suffering from scab, the " sets " should be washed in a dilute solution of *corrosive sublimate,* one ounce of the substance (which is extremely poisonous) being dissolved in two gallons of hot water, in order to aid solution, and when dissolved more water is added to make ten gallons altogether. This solution should be used with great care, and very distinctly labelled. The best way to treat the tubers is to allow the whole sack containing them to be immersed in the solution.

All the moulds which we have so far considered are classed by the botanists as lower fungi. But we now have to consider some diseases, especially of cereals, grasses, and some of the flowering plants, due to fungi of a higher group, termed the *Basidiomycetes.* The species in this group, though differing very much in some of their characters, have this in common—that they all carry a typical conidiophore, which is termed a *basidium,* and which bears on it conidia of a simple character called *Basidiospores.* There are neither endospores nor sporangia. In this group are included the fungi that produce the disease of smut, which plays such havoc with our cereal crops, and also the parasitic fungi of *rust.* In addition, the puffballs, toadstools, and mushrooms are included.

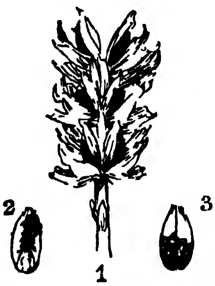
POTATO DISEASE: PHYTOPHTHORA INFESTANS

1. Potato tuber showing disease; 2. Highly magnified portion of under surface of potato foliage-leaf showing filaments (B) of phytophthora protruding through stomata (A) and bearing sporangia (C); 3. Highly magnified section of foliage-leaf showing filaments of phytophthora penetrating the tissues of the leaf. In doing this they absorb the nutriment in the cells.

Those belonging to the smut fungi group are composed of an extremely delicate mycelium, parts of which subsequently become swollen and produce numerous dark spores, often bursting the tissue wherein they live. On it they make the appearance of a black spot, which is termed the smut, from its resemblance to soot.

The smut of oats may usually be seen in the summer months, when the oats are not yet ripened, by the presence on some of the ears of a sooty-looking patch, or powder, that is easily removed by weather conditions. When this happens it is observed that the grain has been entirely destroyed. Only the ears are attacked, the stalk, or the straw, usually escaping,

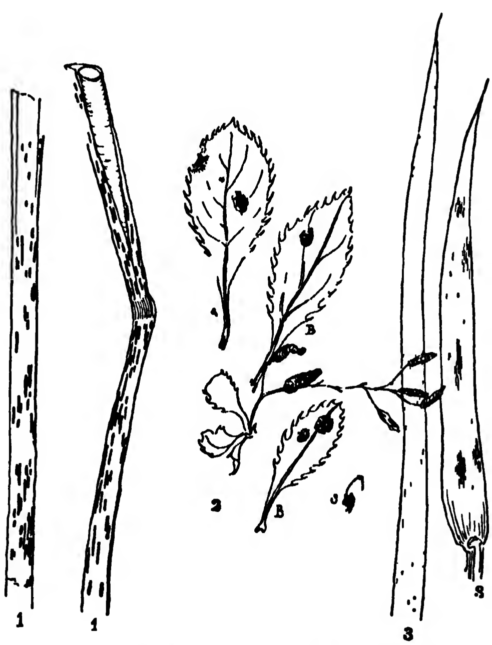
but commonly all the ears on the same plant show the disease. Microscopic examination of this sooty growth shows it to be made up of myriads of the spores of the fungus *Ustilago avenæ*. Each of these is a rounded oval body, which passes the winter in a dormant condition, and springs into active growth later. As can be readily imagined, these spores can be blown about by every breath of wind, on to numerous plants in their vicinity. These, nevertheless, do not become infected. This points to the interesting fact that infection takes place when the conidia in the soil send forth their first growth, doubtless having been sown with the grain of the previous year.



BUNT OR SMUT OF WHEAT

1 Part of ear of wheat affected by smut of wheat, 2 & 3 Grains of wheat affected by smut of wheat (enlarged)

The grain of oats and the spore germinate more or less simultaneously, and it is the first-produced leaf of the oat plant which becomes infected. Apparently, at no other time does infection occur. Later on, when the oats are producing their grains, the fungus grows into the flower, and into the ovary, and feeds upon the endosperm. Here it ultimately produces its spores, and these give rise to the appearance of the smut.



THE STAGES OF WHEAT-RUST

1. Teleutospores on stems of wheat; 2 Aecidiospore stage on barberry (A) upper and (B) under surfaces of leaf showing dark patches formed by the fungus; (C) Fruit with fungus on it. 3 Uredospore stage on wheat foliage-leaves See pages 3324 and 3331

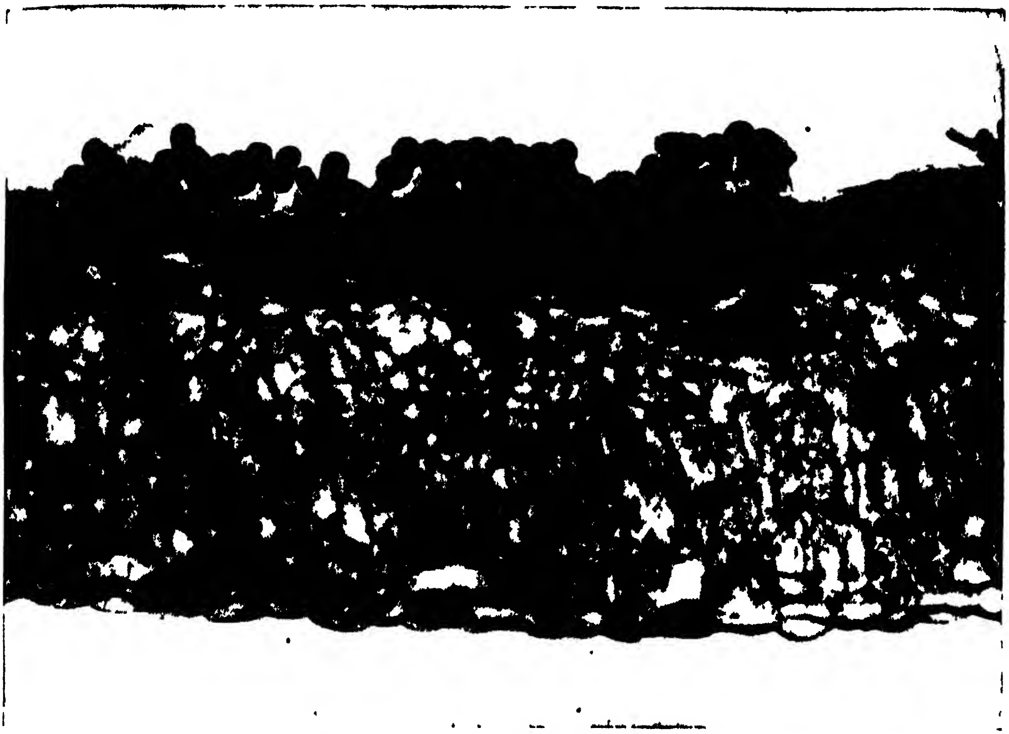
Other species attack wheat, barley, and rye, two species being associated with the smut of barley. One of these is called the *naked* smut, the other the *covered* smut, the former being that usually found in this country. It destroys the ear. The covered smut remains within the ear (hence the name) till the harvest. The smut of rye is somewhat rare.

As soon as any signs of infection with smut of the ears of the barley are noticed, these parts should be plucked off the plant and burned, before the spores are fully ripened. Spores adherent to the grains are easily killed by hot water (at 120° F.), so that seed treated in this way can be used for sowing without injuring the embryo within. It should be mentioned, however, that the embryo of the barley seed is less resistant to the temperature than that of oats, wheat, and rye.

Another method of treatment is to dissolve copper sulphate (1 lb.) in boiling water (five quarts), and pour this solution, when cold, over the grain, spread on the floor of a barn. Or the seed may be soaked in a solution twice as weak as that given. This method of treatment allows a thin covering of the copper sulphate to remain upon the seed, which acts as a protection. It is sometimes spoken of as pickling the seed, and is particularly effective for the smut of wheat, rye, and oats, and for the smut of barley, but it is less efficacious in the case of the covered smut

Another species of the same group of fungi attacks maize, giving rise to great disfigurements, not only on the ears, but also on the leaves and stems of this plant. These, again, are produced by innumerable spores.

A condition known as the stinking-smut of wheat is frequently found in wheat plants that in their early stage gave an extremely robust impression. They are, however, of a bluish-green colour, and later the grains affected—or bunted, as they are termed—are found to be fatter and not so long as a normal grain of wheat, and when cut into are filled with a peculiar black powder, the smell of which suggests the odour of stale herrings. Once more we are dealing with the presence of large numbers of spores, in this case from a fungus called *Tilletea tritica*. The conidia, produced from the mycelium, give rise to growths, which enter into the tissues of the wheat plant. The prevention and treatment of this condition is the same as



ONE-CELLED BLIGHT-SPORES BEING PRODUCED ON A WHEAT LEAF FROM SPORES FROM BARBERRY

See the description on the bottom of page 3334

that already given for smut, and the copper sulphate prescription is very effective.

Rust and mildew are produced by a group of fungi termed Rust-fungi, or *Uredineæ*. They are endophytic parasites made up of very slender mycelia, which attack small portions of the leaves and stems. Their spores assume different forms, whose names we need not specify. The most common species which produces rust and mildew on wheat is a veritable economic pest. The commercial loss to the wheat market from this cause alone is no less than several million pounds per annum.

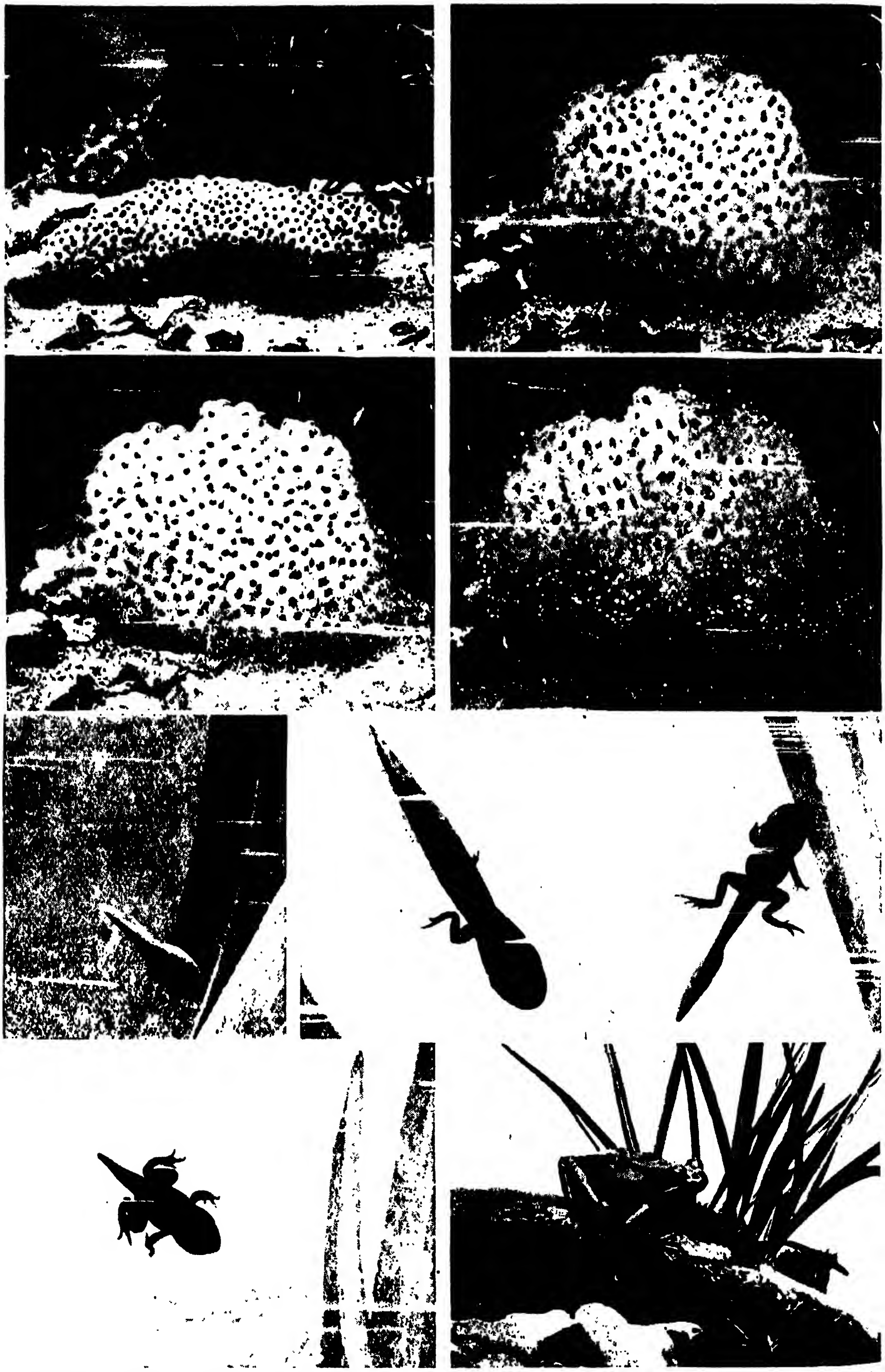
SCAB ON A POTATO DUE TO OOSPORA SCABIES

The wheat affected soon shows a loss of its healthy green colouring, and assumes a yellow hue. This is followed by characteristic appearances of orange-coloured spots on the leaves and stems, that are, as a matter of fact, apertures in the plant out of which powder of the colour mentioned is exuding. This is the stage of rust. Later on, these red spots become black, and this stage is known as that of mildew. Both are caused by different stages of the same fungus—namely, *Puccinia graminis*. The two colourings are to be referred to the production of spores, and this particular species attacks wheat alone.

The last form, or the black spores, lives through the winter in a dormant condition, to resume growth next spring. This fungus attacks some other cereals, and some grasses, in addition to wheat, rye, barley, oats, couch-grass, and other species of plants.

All the varieties described are distinguished by the fact that the spores of one variety cannot infect any other kind of plant than that with which it is specially associated.

THE STAGES IN THE GROWTH OF THE FROG



The first four pictures show a mass of frog's eggs recently laid, and the development of the tadpole within them until it is liberated and changed into a full-grown frog as shown in the lower five pictures.

These photographs are by S. C. Johnson; others on these pages are by W. P. Dando, Lewis Medland, and B. Hanley.

WATER-BORN LAND ANIMALS

The Place of the Frog, the Toad, the Salamander, and the Newt in the Scale of Life

STRANGE STORIES OF LOWLY NURSERIES

NEARLY two centuries ago a Swiss naturalist discovered in the Upper Miocene of his native land the skeleton of a four-limbed vertebrate, and in his enthusiasm bestowed upon it a Latin title signifying "the man who witnessed the Deluge." It became necessary for more scientific investigators to re-name the skeleton. The finder was slightly in error both as to classification and age. The remains were not those of an antediluvian man, but of an amphibian, a giant salamander, belonging to a class of animals whose antiquity, compared with that of man, is as the age of a patriarchal oak contrasted with that of a mushroom.

"A toad, eh?" says the yokel of the familiar story, adding: "I'll larn ye to be a toad!" as he brings his spade down with a whack upon the unfortunate creature's head. The painful lesson, even had the pupil survived to profit by it, would have been superfluous; toads learned to be toads such a very long time before certain lower animals learned to be men. The brute with the spade does not know it, but the toad which he sets out so emphatically to teach is one of the most remarkable links in the long chain of life stretching back to the world's dank and misty twilight. It is an animate chapter-heading in the story of evolution.

The meanest ditch in England, teeming in the spring with its myriad writhing tadpoles, arrests the attention of the student, though Hodge will pass it by, unless primordial savagery impels him to dash the life from a few of the humble creatures in the muddy channel. There, in that stagnant ditch, the story of animal creation is being retold. There is life, as once all pre-terrestrial life was, preparing for the first great adventure of existence, making ready to leave the world of waters, and to struggle, gasping, ashore, to possess the whole earth. Frogs and toads, newts and salamanders and their allies, which together constitute the amphibia, are among the most interesting relics of the past. They are the survivors of the forms which bridged the gulf between fishes and reptiles, whence came birds, mammals, man himself. This is not to say that the first terrestrial ancestor of man was toad or salamander, but it is as certain as anything known in the story of evolution that every order of animals that has ever peopled the earth arose from the amphibian forms of which those to be dealt with in the present chapter constitute the survivors.

We group them in one class of two orders the ecaudata, or tailless, and the caudata, or the tailed; and for general purposes we term the whole amphibia. The first order consists of the frogs and toads, the second of the salamanders and newts. By most people these are all regarded as reptiles cold-blooded, egg-laying animals. But they are not reptiles. The reptile resembles its parent at birth, in that it is not born in water, but is equipped with air-breathing lungs. The amphibia we call water-born animals which come to land to live.

The description is inadequate. Some of the amphibia pass their lives in the water, while some are born on land. That is, therefore, not a sufficiently comprehensive distinction. A further note of identification occurs in the fact that the larval amphibian is born with gills, not with lungs. But even that does not hold good, for certain species do not make their appearance until gills have disappeared and lungs have fully developed. If we relied only upon nursery conditions we should have to call the frog-hopper, or cuckoo-spit insect, an amphibian, or else call one of the amphibia

by the name of this insect. Just as the eggs of the cuckoo-spit are hatched upon shrubs in a mass of froth, so are the eggs of certain forms of these so-called water born land animals. Nor will it suffice to say that an amphibian must undergo a post-natal metamorphosis, for there are frogs and toads which leap from the egg-capsule completely equipped as are their parents, perfect frogs and toads in all but bulk. As against this we have others which attain to parenthood while in the larval condition.

THE EDIBLE FROG

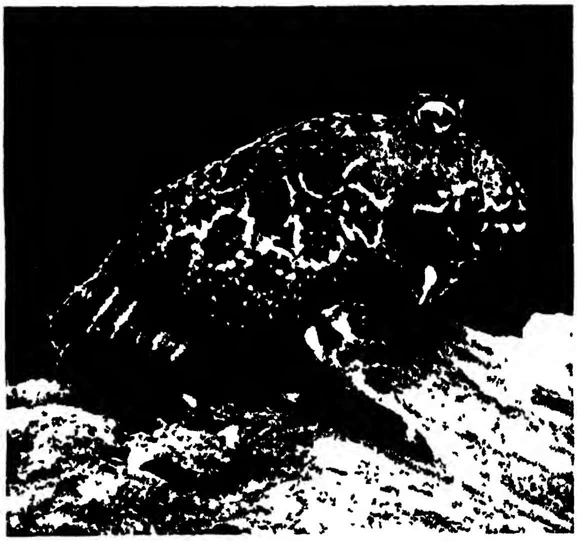
The many exceptions which present themselves to the rule propounded for the classification of amphibia are, as a fact, not surprising, seeing how immensely ancient is the class, how infinitely many the lines along which modification has been able to proceed. The remnant remaining serve to remind us of the origin of the amazing family into which these primitive forms have branched. We cannot, of course, trace all the steps, for the connecting links are missing, but we are clear that the extinct labyrinthodonts, which were themselves not remotely removed from the fishes, connected the amphibia generally with the anomodonts and beaked reptiles. The amphibia to-day have for the most part the same number of limbs with the higher mammals, and those limbs are similar in structure, possess the same number of segments, and are supported by corresponding bones. But in other respects the anatomical economy of the amphibian is far more primitive than that of any other terrestrial vertebrate. How is it, then, it may be asked, that, with many points in common between the amphibia and the higher animals, amphibia themselves have not advanced with the rest of terrestrial creation to become true reptiles, or birds, or mammals? The answer is that, when a class or order attains to a fair measure of generalisation, it has a good chance of continuing in existence under conditions to the average of which it has adapted itself. It is those that become highly specialised which incur the greatest risk. Conditions specially favourable to a particular form of life, when they disappear, leave such form of life practically defenceless. The specialisation already attained must be pushed forward at great speed to enable the animal to face other conditions, or death must be the penalty. Changes in physical and meteorological conditions have been responsible for the obliteration of many highly specialised types of ancient life. The more generalised animal, however, has been better fitted to meet the varying emergencies of fortune.

THE BULL-FROG

A peasant household may produce a king or a line of kings, which line may die out and be forgotten, but the old peasant stock whence such king was derived will continue in the village, healthy, humble, satisfied with its lot, little changed through generation after generation, though its collateral kin tramps victorious across a continent. Thus it must have been with the amphibia. They gave rise to many a line of kings, to all the kings, in fact, that the world has seen—reptile kings, avian kings, mammalian kings—and themselves have remained little changed, while around them their descendants have grown into forms and types such as all the books in the world would fail fully to describe. Many of these descendants were wiser than their parents. They learned to emancipate themselves from the neighbourhood of water, to bring forth their young upon land, and so to claim the fairest places of the earth.

The survivors of the ancestral stock have specialised only in minor particulars.

Structurally, the amphibian of today varies little from the earliest member of the class. Fins of the fish became limbs for progression on land, scales surrendered place to a smooth skin, and not one of the class remains which put on armour of plate or of bony scutes. The warty integument of the toad and the hairy covering of the West African frog (Trichobatrachus robustus) represent but insignificant modifications contrasted with the changes effected by earlier forms which passed on or passed out. Certain of the toads and salamanders have developed poison-glands, from which, in time of peril, a venomous secretion is produced, as from the fang of the snake. That is the only defensive weapon to be found in the whole class, and is correlated with sluggishness of movement.



THE ORNAMENTED CYROIOPHYRUS

The frogs and toads have managed very well in life by depending upon agility—especially so in the case of the frog—and protective coloration to secure them against attack. And there is this striking fact to be noted: that as each member of the ecaudata has become more specialised as to reproductive process, the fewer have become its progeny. Those which possess no special means of safeguarding their young are fruitful beyond belief. The common English frog lays literally thousands of eggs every spring, each of which, it is possible, may produce a tadpole. But no creature is more exposed to danger than the larva of the frog. Carnivorous water-beetles, fish, birds, the cannibalistic propensities of tadpoles themselves, all help to reduce the number of the family. The progeny of a hundred frogs may *drown* if they cannot escape from the water in which they have passed their larval existence. We are not to imagine that frogs have consciously increased their output of eggs simply to make good the mortality among their offspri g; the species has been kept in existence because the progeny which have survived have been those derived from a prolific strain. Those frogs which have developed the extraordinary nursery habits which we are to consider have necessarily lost this great power of increase; they could not rear vast numbers of young in such specialised conditions.

It is to be noted, further, that those members of the class which have accustomed themselves to a circumscribed habitat are least numerous in species and individuals. It will surprise many people to know that the amphibia number so many as a thousand species. It will surprise them still more to learn that the tailless forms, which in the perfect form are more free to wander and get the best out of life than are the salamanders, number nine-tenths of the whole. The class in its entirety is the least numerous in species of all the vertebrates, but the persistence, even in such numbers, of so ancient a type is a fact at which to marvel.

The life-story of the common frog, toad, and newt is familiar to most of us. The female frog deposits a vast mass of eggs in water, where, having been fertilised by the male, they remain untended, and hatch in from ten days to a fortnight, according to the temperature of the water. Frost does not kill the life within the egg, but arrests its development, while heat hastens it. When the larva leaves the egg it is furnished with external gills, which are presently absorbed, and are succeeded by internal gills. Subsisting upon vegetable or flesh food, which it assimilates by means of suction and by means of a pair of horny serrated jaws, the little creature is in appearance a free-swimming fish. Soon, however, the hind legs bud out and push their way through the skin. Considerably later the horny jaws are cast, and the true frog's head appears, the fore-legs are thrust out, the tail is gradually absorbed, and the

little fish that was must come out of the water or die. A carnivorous land-animal is with us, ready to feed upon slugs, worms, and insects of all sorts, which it seizes either with its jaws or by means of the strangely fashioned adhesive tongue that lies with the tip pointing towards the throat. The skin of the frog is smooth and moist; that of the toad is warty and better adapted to the retention of moisture than that of its cousin. The frog, as the prime leaper of the order, is longer in the hind legs than is the toad. The breeding habits of both are very similar, except that the eggs of the toad are laid in strings, not in a mass, as in the case of the frogs.

So much for the common toad and frog, in which the process of development from the egg to the perfect form is in the manner described. There are twenty genera of these frogs, but we need not note them all. Many of them are widely distributed, being absent only from South America, Papua, and New Zealand. In habits they vary considerably, some being more or less arboreal, while others are proficient and persistent burrowers. Among the typical frogs is Rana esculenta, the edible species, which, inhabiting Europe, large part of Asia, and North-West Africa, has been introduced in past generations into both Cambridgeshire and Norfolk. In the first-mentioned county it is popularly known as the Cambridgeshire nightingale, a facetious reference to the power of its vocal organs. Giants there are in these days even among the frogs. The redoubtable bull-frog of eastern North America measures from 7 to 7½ inches in length, exclusive, of course, of the legs, but, to the great disappointment of Americans, this is not the largest of the frogs, place of honour being commanded by Rana goliath, a denizen of the Cameruns, where it attains a length of 10 inches, exceeding by 1½ inches the dimensions of Guppy's frog from the Solomon Islands, whose length matches that of two huge toads—one from Malay and the other from South America.

THE GRACEFUL TREE-FROG

Our departure from the typical frogs brings us to several remarkable groups. The first consists of the flying frogs, as they are called, which, by means of their amply webbed feet, "parachute" from considerable heights in the trees upon which they search for their insect prey. Then we have the forest frogs, largely arboreal in habit, and separated by a considerable distance genealogically from the true tree-frogs. Here are three groups all more or less arboreal, and distinguished by very remarkable breeding habits. The flying frogs deposit their spawn on the broad leaves of bananas or other trees. Certain of the Dendrobatidæ, or forest frogs, place their eggs in damp spots on land, others in the water; and when the eggs are hatched the tadpoles are carried upon the back of one of the parents, the larva adhering by means of its sucker mouth.

In another group, the Rhacophorus schlegii, the female makes a hole in swampy ground, and secretes a fluid, which is beaten by the action of her feet into bubbles. In this her eggs are laid. When the tadpoles hatch the bubbles subside and return to liquid form, in which the larvæ complete their metamorphosis, then escape to water. Among the tree-frogs proper are nest-builders, frogs which join two leaves together to form a cup, and in this cup secrete a frothy mixture, in which the eggs are hatched, and the young remain until they develop internal gills, at which stage they drop from the nest into the underlying water, and there complete their course of development. Here, then, we have the nursery scheme of the cuckoo-spit insect, or, with the water absent, of the paradise fish.

But not all these nest-builders construct their frothy cradles in trees. One of the tree-frogs excavates a hollow basin in the soil, and within it makes its nest of bubbles, and, that done, constructs a tunnel outward from the nest to the adjacent river; and it is by way of such tunnel that the larvæ, as they leave the egg, will instinctively wriggle to undergo their metamorphosis in the water. Some of the species hatched by this process are intolerant of water in their early stages. The tadpoles of a

Brazilian tree-frog, Hyla nebulosa, for example, if taken from their frothy cradle, very soon die if placed in water. Clear water, of course, is meant, for it should be noted here that no amphibian known to man can endure even the slightest degree of salinity in the water it frequents.

It would be interesting to know, by the way, if this really applies to certain frogs of the Australian deserts. Here we have creatures which so fully charge themselves with water that their bodies are enormously distended, and, so fortified, they retire beneath the sand and sleep away it may be a year or more of drought. The point is, do they receive any moisture from underground? Australian rivers flow beneath the sands of the deserts, and can be tapped anywhere in the waste at distances varying between 1000 and 3000 feet, but are so charged with salts as to be useless for irrigation. Are the Australian frogs immune to the effects of water such as this? it may fairly be asked. To return, however, to our nurseries.

The nest of froth is notable enough, but among the nest-builders is an engineer of skill more challenging even than that of the tree-frog already mentioned which makes a basin upon a riverside. There is one

THE MOORISH TOAD

genus of tree-frogs, Hyla faber, a Brazilian representative, which emulates the beaver. This interesting creature constructs a circular dam in the water. Burrowing in the mud at the bottom, it carries up with hands and breast load after load of soil, and with this constructs a perfect rampart, circular in outline, with the parapet raised

THE SOUTH AMERICAN GIANT TOAD

above the level of the water. The base of the defence is made firm and smooth by the creature's body; the walls are rendered hard and watertight by the action of the hands of the frog, which uses these as skilfully as any aboriginal human mason. The result is the formation of a sheltered pool, completely defended against invasion by carnivorous insects and other aquatic enemies of youthful frogs.

So far we have reviewed the habits of frogs which seek external nurseries for their progeny. But there are many genera in which the parent's body is itself the cradle. The best known of this type is the midwife frog, Alytes obstetricans. Here the male receives the eggs as they are laid by the female, which deposits them in long strings. These he winds about his hind legs, and faithfully carries them until the period of incubation is over. As a rule, he retires to some moist retreat near pool or stream, where he is invisible by day. At night, however, he comes out and seeks his food, apparently quite unhampered, occasionally taking to the water, for the purpose, it is believed, of ensuring the requisite degree of moisture for the eggs. The latter are three weeks in hatching, and the larvæ, carried to the water by their solicitous sire just before they break from the shell, swim away at once to take care of themselves.

The female of a Brazilian tree frog, Hyla goeldii, carries her eggs upon her back. The eggs rest tightly glued to the skin of the back, the edge of which is slightly raised to preserve the embryos in place. When the capsules burst, young frogs emerge, not tadpoles, frogs with mouth and limbs complete, but with the tail which distinguishes the last days of the larval stage of the common frog. In cases such as this, where precocious development occurs, some special provision is always to be noted for the breathing of the young amphibian. To take the place of the gills some unique adaptation is to be discovered, either in the form of a tail richly charged with blood vessels, or some particular excess of skin similarly equipped, by means of which oxygen can be absorbed directly into the blood.

THE MENOPOMA: A REPRESENTATIVE OF THE FISH-LIKE SALAMANDERS

The Surinam toad has advanced beyond the methods of the two genera of frogs last mentioned. In this case the female receives the eggs upon her back, where they are placed in position by the hands of the male. Here, however, the eggs are not allowed to remain exposed. The skin of the female grows round and over them, so that each egg is enclosed in a cell of the mother's external integument. As many as five score eggs are carried in this manner by the female, and from each cell a perfect little frog ultimately emerges. Thus the complete metamorphosis is undergone without risk of exposure to animal enemies in water or nest.

THE SPOTTED SALAMANDER

More specialised still is the nursing plan of certain South American tree frogs known as the Nototrema, or pouched frogs. In this instance the female, at the approach of the breeding season, develops upon her back what may be described as a marsupial pouch. In this the male, by means of his hind legs, places her eggs, where the young are hatched in safety. There are several species of these frogs, and it is significant that where the larvae escape into the water in tadpole stage the eggs are numerous, as if to cover all risks; but where the young are produced as frogs, then the eggs are few, sometimes only three or four, never so far as is known more than sixteen or eighteen. It is not only in any one species or genus that the larvae undergo full development before passing out into the world. There is a mountain-haunting frog of New Guinea (Phrynixalus biroi) which deposits its eggs in an elongated transparent membrane, and leaves all to hatch out as they will. And here the little ones do not appear until they have passed the tadpole stage. Still the list of strange nurseries is not exhausted. One of the most remarkable of all remains, that of Darwin's frog (Rhinoderma darwinii), the male of which has so modified its vocal sacs as to convert them into receptacles for the eggs of his mate. The pouch, which becomes an extensive chamber on the under surface of the body, is entered by two channels, situated on the floor of the mouth, and into this the most

...ious of all nurseries in terrestrial animal life, the eggs are received there to remain until the young, numbering a dozen or more, have not merely quitted the egg but passed through the larval stage.

Modifications and adaptations are to be traced in many directions in addition to the reproductive habits of the tailless amphibia. We have noted the flying frogs and the tree frogs, the latter furnished with sucker discs to their toes resembling those of certain lizards. It is not difficult to imagine how this feature developed, for everyone who has kept and bred frogs is aware that the young batrachian, even of the common British species, has for some days after quitting the larval stage the power of climbing up a perpendicular surface simply by the sucker-like action of its clammy little feet. This power departs, however, from the adult frog.

THE AXOLOTL

Other strange examples of amphibian life are the narrow-mouthed frogs, the short-tailed frogs with enormous balloon-like bodies, the fantastic sharp-nosed frog of the Solomon Islands, the horned frogs of tropical America, which, with a length of eight inches or more and great bulk, are the most ferocious of the order, preying upon other frogs and small mammals and venturing, in self-defence, to attack human beings. The piping frogs too are famous not less for their music than for their nests, carved out of the mud in such a position that the larvae, when they emerge, will be released by a timely flood and gently carried into the river. These frogs belong to a sub-order remarkable for the entire absence of a tongue, a peculiarity shared by the Surinam toad and the spur-toed frogs or toads. Of these the smooth spur-toed toad or frog is exclusively aquatic, pursuing even its prey under water and effecting their capture by means of the fore feet.

THE OLM FROM THE CAVES OF CARNIOLA

The second order of the amphibia, the salamanders and newts, have not been so closely studied as the frogs and toads. Newts are generally regarded as poisonous, and salamanders are credited with occult powers of withstanding, and of rather enjoying, the flames of the fiercest fire. The whole order is exclusively nocturnal, and in place of actual knowledge a body of myth and legend has grown up around the order, which it will take ages finally to dispel.

So limited has been our knowledge of some genera that it was not until the other year that we knew the formidable autodax, so called in reference to the teeth with which it defends itself against attack, lays its eggs in trees. The discovery, which, in view of our insufficient knowledge of the subject, was of great importance, was accidentally made in the grounds of California University, where men cleaning and dressing the trunks of oaks found strings of eggs in holes thirty feet up the stems of the trees. At first regarded as a freak on the part of a single salamander, the position of the eggs was found to be normal. The autodax does actually dwell amid trees, and there lays its eggs and broods them with great devotion.

This example of solicitude is not isolated, nor is the autodax the only member of the order to frequent land for the rearing of its young. The Alpine salamander, for instance, which ranges between heights of from 2,000 to 10,000 feet up the Alps, not merely avoids the water for her nursery, but produces her young alive, and that by the most curious process yet observed. Of fifty eggs which the oviducts may contain only two are fertile. The tadpoles when they emerge from the egg are not at once extruded from the parent body, but are nourished upon the substance of the remaining eggs, so that the favoured pair undergo their metamorphosis amid an abundant food supply and emerge in the likeness of the parent form, from which they differ only in point of size. The spotted

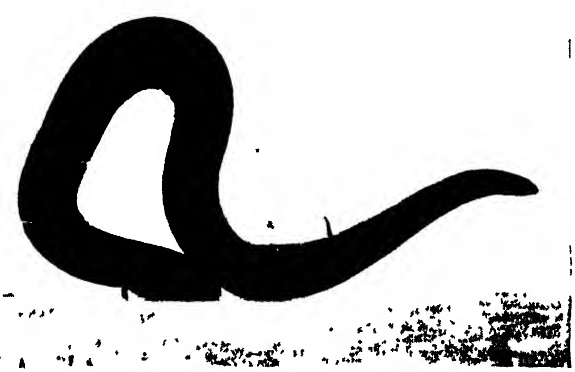
salamander may be said to be both oviparous and viviparous, since both eggs and tadpoles may be produced at one and the same season.

Included in the best-known groups of the salamander tribe are the spotted, the spectacled, the Spanish, the Caucasian, the several genera of cave-dwelling salamanders, and the famous axolotls. Among the cave-dwellers are some which pass their lives in subterranean waters. The complete story of these has not yet been told.


THE SIREN OR MUD-EEL, A TWO-LEGGED SALAMANDER

Twenty years ago we knew nothing of Typhlomolge rathbuni, when from an artesian well at San Marcos, Texas, 188 feet deep, a dozen specimens of a strange, semi-transparent, slender-limbed salamander were cast up, furnished with external gills, and having the eyes functionless. Even now we do not know whether this is the larval form or the adult, but opinion inclines to the former belief. The life-story of the axolotl is responsible for this belief.

The axolotl, common to many parts of the United States, is, for ordinary purposes of identification, not greatly different from other salamanders, and its young undergoes the usual larval metamorphosis resembling that of our common little newt. But the case is different in certain lakes by which the city of Mexico is surrounded. One of these lakes is brackish, and contains no form of amphibian life. In the fresh-water lakes, however, axolotls abound. But here these creatures never advance beyond the larval stage. That is to say, they never become air-breathers in the ordinary sense, but retain their gills throughout life. They were found to resemble the amblystoma in all but the vital point as to breathing.


THE AMPHIUMA OF NORTHERN AMERICA

The amblystoma passes through the ordinary larval stage and acquires lungs, and becomes an air-breather; the Mexican axolotl remains a water-breather. Naturally, then, the two salamanders were referred to different genera. It was accidentally discovered at the Paris Jardin des Plantes that axolotl and amblystoma are one and the same—that the former is simply the larval stage of the second. When water in their tank was diminished, the axolotls rapidly lost their gills, developed lungs, and became air-breathers in the ordinary sense. They had become amblystoma! Yet in the Mexican lakes in which they flourish, for some reason which naturalists have not yet been able to fathom, they never pass beyond the larval condition. They issue as larvæ from the eggs, they develop as larvæ, and they breed as larvæ, yet every one of them is capable, we are to believe, of turning into the adult form of the amblystoma. And possibly each would do so were the supply of oxygen in the water insufficient, so compelling them to draw upon the atmospheric air for supplies.

The salamander from the Texan well has a famous relative in Europe in the olm. This is an eyeless gilled salamander, dwelling in the subterranean waters of caverns in the Alps of Carniola, Dalmatia, and Carinthia. We know not upon what it feeds in its natural state, but in captivity it takes, when so inclined, small worms, crustacea, and minute forms of life found on aquatic plants. It is very sensitive to light, and endeavours to shift into a dark corner of its tank should a sunray illumine the water. It has been found to breed in captivity, sometimes producing eggs, sometimes live young, but all attempts have so far failed to cause it to substitute gills for lungs.

Another curious form of salamander is the mud-eel of the south-eastern United States, which is compared to a snake with external gills and a pair of short fore legs. Then there is the Georgian two-legged salamander, which has both gills and lungs. This salamander has been proved, again by accident, to be really independent of the former organs, a fish in an aquarium having devoured the gills of one which afterwards lived unhampered, depending upon its lungs for oxygen supply. Then there are the cæcilians, blind, limbless amphibia, which, when they quit the larval stage in the egg-mass deposited in mud or other damp situation by the parent, escape to the water to complete the metamorphosis, returning afterwards to land for the rest of their lives, to burrow in mud and soft, damp soil, and lead a worm-like existence, in all but the matter of diet, which is carnivorous.

THE SMOOTH NEWT SWIMMING AND AT THE BOTTOM OF A POND

Our review closes by a return to the commoner forms of the order, the fish-like salamanders, so called from the fact that these, which constitute the family Amphiumidæ, are entirely aquatic. It was one of these, a giant salamander, whose remains startled the Swiss naturalist into the belief that he had found a man who had witnessed the Deluge. The first living representative of the giant salamander was discovered nearly a century ago in Japan, and one was first brought to Europe in 1829. Its supply of fresh-water fish unfortunately failing on the voyage, the male ate its female companion, but dwelt apparently without remorse in a comfortable aquarium at Amsterdam for fifty-two years.

THE CRESTED NEWT

Giant salamanders live in the mountain streams of Japan and China, and are never known to quit the water. The eggs are carefully tended by the male, which coils itself round the mass—numbering some 500—until, at the end of about ten weeks, the young emerge. They differ little from the tadpoles of salamanders and newts, possessing in the early stages of their existence gills that are afterwards lost.

Little need be said of the newts. The fertilised eggs are attached by the female to leaves of aquatic plants, and the young, upon emerging, bear gills resembling those of toad and frog. But whereas in the latter the hind legs always first appear, with the newt it is the fore pair which first develop. In the adult stage the newt takes to the land and seeks damp, secluded situations, returning to the pool only at breeding-time. They are very elusive little creatures. Of scores turned loose by the present writer in a small lake, not one is to be found today, though the locality must be teeming with them. One which was caught and confined, for later inspection, in a flower-pot on a hot day died in the course of two or three hours, dried up!

There is yet much to learn as to the life-story of many of the amphibia. They are, despite their lowly organisation, among the most interesting relics of the past still preserved to us, and by their history maintain intact the bridge from which life passed out of the waters into the great world beyond. They have still many secrets to declare to the student who will diligently seek and observe. Even the common frog can yet teach the average "expert" humility in knowledge.

THE PAINTING ENTITLED "THE NAUGHTY CHILD," BY SIR EDWIN LANDSEER

INSTINCT AND EMOTION

The Deep-Seated and Universal Influence of Instinct, and Its Inseparability from Emotion

THE MODERN STUDY OF PSYCHOLOGY

We are now about to plunge into what St. Augustine called "the abyss of the human mind." We have studied the senses, the memory, the mechanism of speech, and we have to look now at what Wordsworth, in his noble poem on his wife, called "the very pulse of the machine." It feels, is impressed, combines, and retains impressions, but, furthermore, it does things. Why and how? All that we have yet dealt with is only preliminary, after all, though there are many past text-books which deal with nothing else, as if the intelligence were the whole of man. The intelligence is only a method, a mechanism, a mode of direction—for the purposes of That whose purposes they are, and whose intelligence it is. We must get down to the springs of action, to the very pulse of the machine.

In the study of reflex action, we saw how living creatures, including ourselves, may and do respond to stimuli. Light is felt, and the pupil of the eye contracts; a fist approaches, and the upper eyelid falls; we sit on a pin and rise rapidly, perhaps with a reflex expletive in addition. These are more or less simple "reflexes," or reflex actions, and the study of them does not take us far enough when we want to understand the behaviour of man. Nevertheless, we note that these responses, though in a sense automatic and mechanical, are yet not without meaning. They are for life. They express the intention and purpose and construction of the living thing *to live*. They are the mechanical expression of purpose, just like a machine, a gun, or a locomotive or an electric piano, made by man and caused to "go" by means of the appropriate "liberating stimulus."

When we look at certain other kinds of behaviour, evidently more complicated, such as throwing oneself into a fighting attitude or into another person's arms, or when we see a puppy or a child devoting itself to the examination of some novelty, we recognise a sort of resemblance to mere reflex action. These higher types of action we call instinctive; and we know well that a vast variety of human behaviour, in small things and in great, belongs to this class. It is instinctive, natural, follows impulses which arise within us, of which we are conscious, but which, in a sense, we cannot be said to have invented. We "find ourselves irresistibly drawn" to do this or that, as the moth flies to the light, or the infant's hand feels for its mother's bosom. If we believe in the doctrine of organic evolution, as we all do, we must try to trace and define a connection between those lowest forms of conduct by which, say, the amœba, "sensing" something edible, approaches it, and those by which a hungry man follows a sniff of an adjacent restaurant, or works night and day for money wherewith his children may be fed when he is dead.

The first, and in many ways the greatest, student of this subject was Herbert Spencer, whose "Principles of Psychology," published before the "Origin of Species," are actually approaching their sixtieth birthday. Having recognised the theory of evolution to be a universal truth, Herbert Spencer sought to apply it to what is, after all, a greater thing than the evolution of solar systems or nebulæ—namely, the evolution of mind. Thus he reached the conclusion that "instinct may be described as compound reflex action." In the simplest reflex a single impression educes a single response; in the working of instinct many impressions combine to produce a manifold response; "and the higher the instinct, the more complex are both the directive and the executive co-ordinations."

Probably Herbert Spencer cannot guide us much further in this direction. We are

grateful for his help thus far. No doubt his definition is true and useful, so far as it goes. But, after all, it is only a physiological definition; it is only in terms of machinery, and it does not even allude to the psychical side of what is going on. Now, there *is* a psychical side. We may observe the amœba or the puppy, and define its actions as reflex, simple or compound. But when we proceed to observe ourselves doing just similar things, in the presence of similar stimuli—food, novelty, danger, attraction—we cannot fail to notice that there is something more than machinery to reckon with.

The Combination of how We Effect with how We are Affected

While we do what we do we also *feel*. We enjoy, or fear, or hate, or are curious, or what not. If, perchance, we also happen to think, we shall doubtless credit the puppy, at least, with feelings not incomparable with our own; and thus we have established the fact that there is a psychical side to instinctive action. We not only effect, but are affected. Psychologists thus often and conveniently speak of the "affective" aspect of instinct.

But we heard nothing about this from Herbert Spencer, and yet it has only to be experienced, at absolute first-hand, in and by ourselves, for us to admit that it is at least as real and as important as anything in the world. To hate, to fear, to welcome, to love, to be interested in—these are part of the very deepest and most *e*ffective, because the most deeply *a*ffective, substance of our being. We must make a fresh study of instinct, plainly, for, in terms alike of action, of behaviour, and of feeling, this is at the very heart of things.

And psychologists have been steadily studying instinct ever since Herbert Spencer laid the foundations of the new psychology, which is based upon Life, and is in living contact with physiology from first to last.

Getting Free from Chaotic Uses of the Word "Instinct"

Two notable students on the subject, in especial, must be consulted, the late Professor William James, of Harvard University, and Dr. William McDougall, of Oxford University, who has, by now general consent, carried our knowledge of this subject far further than ever before. But first, lest we lose ourselves hopelessly, we must properly define our terms. "Instinct" and "instinctive" are used so loosely in ordinary speech that they have almost ceased to have any meaning. As Dr. McDougall says: "On the one hand, the adjective 'instinctive' is commonly applied to every human action that is performed without deliberate reflexion. On the other hand, the actions of animals are popularly attributed to instinct; and in this connexion instinct is vaguely conceived as a mysterious faculty, utterly different in nature from any human faculty, which Providence has given to the brutes because the higher faculty of reason has been denied them."

Thus we are told that people have an "instinct of subordination," that ancestor-worship is a "mere tradition and instinct," that if a drunkard is fed on fruit he will "become instinctively a teetotaller," that "the Russian people is rapidly acquiring a political instinct," that "the instinct of contradiction, like the instinct of acquiescence, is inborn." Such absurd and chaotic instances show that the words in question are commonly used as cloaks for ignorance and are substituted for any attempt to understand individual or collective actions which we are too lazy to analyse. Perhaps everyone uses the words in such ways in ordinary speech, but they must not so occur here.

Instincts—Innate Elements Not Acquired During the Individual Lifetime

In our discussion of "instincts" here we shall mean what the serious students of the mind always now mean by that term —"innate specific tendencies of the mind that are common to all members of any one species, racial characters that have been slowly evolved in the process of adaptation of species to their environment, and that can be neither eradicated from the mental constitution of which they are innate elements nor acquired by individuals in the course of their lifetime." An instinct is thus something natural, genetic, and is the very opposite of a habit. Acquired habits of action, such as play a great part in our lives, may be called "secondary automatisms," and require careful study. The possibility of acquiring them may have an instinctive basis, but they are not instincts; and no writer of today who is really trying to find the facts of human nature ever says instinct when he means habit, or habit when he means instinct. Those who cannot perceive and steadily maintain in their minds the difference between what one does because one is so made, without any previous experience or understanding, or imitation or education or suggestion, and what one does because one has learnt, say, to write, and with one hand rather than the other—those unfortunate people should not attempt to proceed further with

psychology, where their predecessors have already caused muddle enough.

Let us go to a great student of the behaviour of insects for further illustration of this all-important distinction. In the preface to Professor Forel's book on "The Senses of Insects," lately translated into English by Mr. Macleod Yearsley, the indefatigable champion of children's hearing, we find excellent definitions of true instinct, and of its ally and opposite, which is not instinct. Instinct in insects, as elsewhere, is inherited, like limbs or heart or muscles; "it is constant in effect, adapted to the circumstances of the special life of the species . . . this curious instinctive adaptation which seems so intelligent when it carries out its proper task, so stupid and incapable when diverted to some other purpose."

The Simplest Life Endowed with a Power of Adaptation

But, as Professor Forel insists, and his study of insects applies no less to ourselves, the living creature has also a power of personal adaptation, a "plastic or adaptive activity," which is other than instinct, but is its equal in importance. As he says, this personal power of dealing with circumstances is primitive. "It is even the fundamental condition of the evolution of life. The living being is distinguished by its power of adaptation. The amœba is plastic." By means of this power the living creature opens up new paths for adaptation to the unexpected, preparing by repetition secondary automatic activities which we call habits. Hence Professor Forel reaches the following conclusion, which must be exactly quoted, for it dates as far back as 1900, and is notably similar to the teaching of Professor Bergson in his "Creative Evolution":

A Special Automatic Activity that Reaches its Summit in Insects

"To sum up, every animal possesses two kinds of activity in varying degree, sometimes one, sometimes the other predominating. In the lowest beings they are both rudimentary. In insects, special automatic activity reaches the summit of development and predominance; in man, on the contrary, with his great brain development, plastic activity is elevated to an extraordinary height, above all by language, and before all by written language, which substitutes graphic fixation for secondary automatism, and allows the accumulation outside the brain of the knowledge of past generations, thus leaving to the last the forces necessary to his plastic activity, at once the adapter and combiner."

This might be a passage from Bergson, except that the French philosopher would scarcely allow even so much of instinct in the make-up of man. As the reader will remember, Bergson sees in the insect the instinctive and in man the intelligent creature, and he has very little to say of instinct in ourselves. Here he follows the older view of the psychologists of the nineteenth century, who were inclined to suppose that instinct had all but lapsed in man, and that intelligence had taken its place. They did not see that intelligence *does* nothing; it points, but it does not push. They regarded man as a creature with only very few instincts, and those weak and rather objectionable or derogatory to his dignity, for he is the reasonable creature, while the lower animals, they said, are not reasonable or intelligent, but behave in accordance with a great number of instincts with which they are endowed. It is perhaps the most serious objection to M. Bergson's philosophy that he accepts this far too violent antithesis almost wholly.

The Contention that Man has as Many Instincts as the Lower Animals

But, now more than twenty years ago, in his "Principles of Psychology," Professor William James set himself against the then generally accepted notions. All agree that man has been evolved from ancestors whose actions were mainly instinctive, but we can no longer assent to the view that, "as man's intelligence and reasoning powers developed, his instincts atrophied, until now in civilised man instincts persist only as troublesome vestiges of his pre-human state, vestiges that are comparable to the vermiform appendix, and which, like the latter, might with advantage be removed by the surgeon's knife, if that were at all possible." James declared, on the contrary, and indeed proved, that man has at least as many instincts as any of the animals, and that they play a leading part in the determination of human conduct. And now Dr. McDougall writes that "this recognition will, I feel sure, appear to those who come after us as the most important advance made by psychology in our time."

No doubt the notable feature of instinct in mankind is its great modification by the intelligence, and by habits acquired under the guidance of intelligence or by imitation. Further, in man this modification is made

possible by the very development of his instinctive powers a slow development which has long caused us to misunderstand their true character, and to put down as habit what was *not* "second nature," but *first*. In mankind the instincts, though innate (like a man's beard), are, with few exceptions, undeveloped in the first months of life, and only ripen or become capable of functioning at various periods throughout the years from infancy to puberty, or later still.

The Instinct that is in Ignorance of the Purpose for which it Exists

A single instance will suffice to show, once and for all, what we mean by a true instinct, in a highly developed form. "The mason-wasp lays its eggs in a mud nest, fills up the space with caterpillars, which it paralyses by means of well-directed stings, and seals it up; so that the caterpillars remain as a supply of fresh animal food for the young which the parent will never see, and of whose needs it can have no knowledge or idea."

Here we see, in sharp outline, that notable fact of instinctive behaviour upon which James insisted its ignorance of the purpose for which it exists. There may be exceptions to this rule in the case of the lower animals, as there certainly are in man; but in them and in man it is true that, even though the purpose be perceived, it is not the perception of the purpose that impels to action. This is something deeper than foreknowledge, anticipation, conscious volition. How the mason-wasp, for example, can do what she does, having never done it before, having had no tuition, having never seen it done, nor having any slightest inkling of its clear, precise, exquisitely achieved purpose—that is a question which we cannot attempt to deal with now. The point is that this independence of intelligence, of memory of the past or prevision of the future, is a characteristic mark of instinct; and our appreciation of it will help us to realise the true nature of instinct, and the stupidity of using this word to mean anything or nothing, as we commonly do.

An Instinctive Basis for All Behaviour Without Exception

If the case of the mason-wasp engaged in life's eternal business of maintaining itself against death seems too remote for our own case, let us take the instance of the youth who falls in love. Among the higher types of men love means much more than mere "reproductive instinct," and may cease to have any effective or necessary purpose of that kind. But that is its root. Herbert Spencer long ago pointed to this case to show instinct's independence of experience. The boy has never been in love before. He may have been brought up in such circumstances that he has never seen its manifestations, or, if he has, he has laughed at them, without the slightest understanding. But now life calls to him, and it is his turn. Habit, experience, initiation, understanding, appreciation of the vital purpose of it all these are utterly absent, but the boy falls in love, nevertheless, as he was made to do. Here is the case of an underlying instinct about which there could be no doubt, and of which no one could pretend either that it was an acquired habit or that it was practically the same as one. The argument now is that, if we look more closely, we shall see the instinctive basis for other forms of behaviour for many, for *all without exception*.

We said that Herbert Spencer's definition of instinct was inadequate because it only described machinery. But instinct is palpably more than mechanical, even when we look at it from the outside. A mechanical process is arrested by any sufficient mechanical obstacle, but we all know that "Love laughs at locksmiths."

An Analysis of what Every Instinctive Act Involves

In more academic language though no more accurately than our illustration "the process, unlike any merely mechanical process, is not to be arrested by any sufficient mechanical obstacle, but is rather intensified by any such obstacle, and only comes to an end either when its appropriate end is achieved, or when some stronger, incompatible tendency is excited, or when the creature is exhausted by its persistent efforts."

And when we look again at an instinctive action from the inside, as we observe it in ourselves, we can recognise not only that it has its psychical side, but that this psychical side is threefold. We must understand it clearly if we are to be prepared for the great advance in psychology which we owe to Dr. McDougall, and to which we are coming. Every instinctive act involves (1) a knowing; (2) a feeling; and (3) a trying. We see or perceive some object, we have certain feelings about it, and we strive in relation to it, towards it or away from it, or for it or against it. These feelings and strivings, however we shall afterwards define them, lie very deep in our nature, and affect our estimate and valuation of life

beyond all else. It is in terms of them that we find life worth living or worthless, that we are happy or miserable. In more technical language, "the continued obstruction of instinctive striving is always accompanied by painful feeling, its successful progress towards its end by pleasurable feeling, and the achievement of its end by a pleasurable sense of satisfaction."

Never again, as in Herbert Spencer's definition, must we neglect the psychical side of instinctive processes, for it is all-important. Here is the conclusion of Dr. McDougall's fine chapter, which has been read with gratitude and appreciation by psychologists throughout the world in the last four years, and to which every writer on these subjects must hereafter be permanently indebted.

The Instincts the Prime Movers of All Human Activity

"We may say, then, that directly or indirectly the instincts are the prime movers of all human activity; by the conative [will-ful] or impulsive force of some instinct (or of some habit derived from an instinct), every train of thought, however cold and passionless it may seem, is borne along towards its end, and every bodily activity is initiated and sustained. The instinctive impulses determine the ends of all activities, and supply the driving power by which all mental activities are sustained; and all the complex intellectual apparatus of the most highly developed mind is but a means towards these ends, is but the instrument by which these impulses seek their satisfactions, while pleasure and pain do but serve to guide them in their choice of the means.

"Take away these instinctive dispositions with their powerful impulses, and the organism would become incapable of activity of any kind; it would lie inert and motionless like a wonderful clockwork whose mainspring had been removed, or a steam-engine whose fires had been drawn. These impulses are the mental forces that maintain and shape all the life of individuals and societies, and in them we are confronted with the central mystery of life and mind and will."

The Myth that Philosophers See Things by the White Light of Pure Reason

Observe, now, before we broach what seems to be another subject, how these conclusions bear upon the popular notion of the mind as a structure with watertight compartments. We talk and think as if the mind were really made of separate things, such as, for instance, the intellect and the will, the realm of reason and the realm of desire. Desire is thought to be a lower type of mental component, so that the ancient Stoics taught that the wise and good man must extirpate all emotion from his bosom, while even the great philosopher Kant taught that "the wise and good man should be free from desire."

It was further supposed that not until the wise and good man had accomplished this feat could he justly and securely reason. Other people saw things through a mist of feeling and prejudice, which gave everything the "couleur de rose," or tinged it with jaundice. But the real philosopher must see things "as they are," by the white light of pure reason, the "lumen siccum," or dry light which faithfully recorded facts, without caring one way or the other.

If we go back to the great writers, for great they undoubtedly were, of the nineteenth century, to Mill and Spencer and Tyndall and Huxley, we find ourselves being constantly exhorted to divest ourselves of any desire to find any particular truth, but to follow the pure light of reason, wherever it led. There was more than a suggestion that it was this desire to find such-and-such that led theologians, metaphysicians, women, and all sorts of other people to believe absurdities and trivialities.

The Universality of Desire with Strong Personal Instinctive Motive

Meanwhile their critics could not go wrong, for they had no desires or prejudices or preferences (or motives, that would mean !), but used the "lumen siccum" alone. They did not realise that without desire no one acts, and that their own faithful research and passionate exposition was the best evidence in the world that they, too, like all the rest of us, were affected by the universal tendency to know what one wants in the way of beliefs and to see that one gets it.

Professor Tyndall's famous Belfast address is a case in point. In it there occurs the fine passage: "But there is in the true man of science a wish stronger than the wish to have his beliefs upheld—namely, the wish to have them true." A noble sentiment, which we may all take to heart; but the speaker did not realise that the scientific passion for truth has itself an instinctive basis, and that we each of us have an instinctive structure which not only determines our search for truth, but our appraisement of it and our identification of it as true. Tyndall himself says further on that "without moral force to whip it into action the achievements of the intellect

would be poor indeed." Nay, more; we now see that without some kind of instinctive impulse within us, whether moral or immoral, the achievements of the intellect would be nothing at all. The "pure intellect," the "lumen siccum," the "philosophic detachment from desire"—all these are myths, which never were nor will be. Let us aim at Tyndall's ideal, let us remember his warning, but let us fully realise, all the time, that desire, personal and particular in each of us, is the motive of all our doings, including the embrace of one we love, or the faithful calculation of angles in a trigonometrical problem. If we conquer desire and prejudice in the lower sense, that is only because we come under the sway of higher forms of desire and nobler prejudices.

The Combative Instinct of Eminent Exponents of Philosophic Calm

It would perhaps be worth while, and it would be only too easy, to trace the influence of desire and of prejudice in many and many an observation of the thinkers whom we have quoted. Anyone reading them now, without reference to the circumstances of the time, will marvel how Huxley could have said this, and Spencer that, and may incline to suppose that these men were sometimes very poor thinkers, after all. But reconstruct their emotional *milieu*, so that we see the entrenched forces, the bitterness, the narrowness, the insolence against which they had to fight, and we see at once that these men were themselves animated by inevitable prejudices and desires, no less certainly than the opponents whom they decried on that very same account. When a bishop could ask Huxley, at a British Association meeting, whether it was through his grandfather or his grandmother that he claimed descent from a monkey, can anyone suppose that the "lumen siccum," or the disengaged, volitionless, careless intellect was much more in evidence in those days, even among men of light and leading, than in any other?

The Discarded Comparison Between the Emotions of Man and Instincts of Lower Animals

In fact, everyone who has ever written a sentence of argument, or who has ever sought for facts in his life, knows all the time that he is moved by desire of some kind—moved, guided, prompted, checked; that it verily "forces" the facts upon him, from Nature's pack, as a conjurer "forces" a card upon his patron. The desire may be for money, to prove oneself right, to prove one's friend right, to prove someone else wrong, to prove the rightness of the rest of one's beliefs (a dominant motive in the highest minded), to be useful, to be cheering. But there always is desire behind us all, and without it we should never stir a step, mind or body.

Let us turn now to another question. Feeling, desire, emotion—all these are words which insisted on turning up in the foregoing discussion. What, in fact, is the relation between emotions and instinct? Some relation there certainly must be. In still recent years, and even now in the estimation of those who have not followed the advance of psychology, the emotions of man corresponded to the instincts of the lower animals. The view was, of course, that man had very few instincts; little, indeed, besides the reproductive instinct—whence, by a train of morbid and childish association, the idea that instinct in general is something "low" and unworthy of man—and hence, when the evident resemblance between an angry man and an angry dog was observed, it was necessary to assume that the dog was acting—low hound—under the influence of instinct, while the man was moved by emotion.

What the Most Delightful of All Writers on Psychology Taught

A little honest thinking will suffice to show that there is something wrong here; and perhaps we should be nearer the truth if we dropped the assumption that the man and the dog are so utterly different, the man a "reasoning being" and the dog a mere dog, the one being guided by his Godlike intelligence and the other by its animal instincts. Indeed, we shall see in a moment how certain and evident is the truth when we drop these insolent assumptions.

But first, for the sake of the historical interest and also on account of its general acceptance by the mass of amateur psychologists today, let us look at the theory of the emotions which was independently advanced by Professor James and by the German writer Lange, many years ago, and which is therefore technically known as the James-Lange theory of the emotions. Beyond dispute, Professor James (whose brother is the famous novelist Henry James) was the most brilliant, easy, irresistible, and delightful to read of all writers on psychology. He had "a way with him" which no one could resist. Every psychologist is immensely indebted to him for his ideas, his *élan*, his fertility of illustration, and the enhanced interest which one felt in every subject which he handled.

THE DAWN OF SIMPLE INSTINCTS

INSTINCT IN INFANCY—"MASTER BABY," BY SIR W. QUILLER ORCHARDSON, R.A.

INSTINCT IN BOYHOOD—"I WILL FIGHT," BY PHILIP SIMPSON

Never was man better suited for the advocacy of a brilliant paradox; and there can be few readers of psychology who have not been to some extent under James's spell, above all in the case of his theory of the true nature of emotional actions and the true order of events therein.

According to this theory, which made a great sensation in psychological camps a quarter of a century ago, we are all quite wrong when we think that we cry because we are sorry, or tremble and run away because we are afraid. That, according to James, reverses the true order of events. In point of fact, we cry or tremble instinctively, by "compound reflex action," and *then* we become conscious of the trembling, or the wet tears, or the palpitating heart, or the fleeing limbs, and this consciousness of the organic changes in our bodies is the emotion. We do not cry because we are sorry, or run away because we are afraid, but we are sorry because we cry, and afraid because we run away—or, even if we do not run away, because we feel the beating heart, the over-acting muscles of respiration, the dryness in the throat.

Objections to the James-Lange Theory of Emotional Action

Thus, in Professor James Ward's words, "Professor James's main position is that an emotion is but a sum of organic sensations," or, in the present writer's definition of the theory, "the state of consciousness which we call emotion consists in a perception, as a united whole, of the sum of organic sensations which are aroused by the internal changes produced reflexly by the object or cause of our emotion." This is, to some extent, a theory which is capable of being put to the proof, and the evidence is against it. Professor Sherrington, of Manchester, a patient and leading student of response, found that, after the performance of an operation which prevented impulses of internal origin from reaching the brain, dogs still exhibited the symptoms of emotion when their instincts were excited.

The facts are against the James-Lange theory, but we can all of us see that there is something in what the theory asserts. It is true that one's feeling of wet tears, a grimacing face, one's hearing of one's own sobs, contributes to the feeling of being very sorry for oneself. It is true that discomfort is increased by palpitation, and that when you run away from a noise in the dark you are more frightened than ever. It is profoundly true that, if we apply the James-Lange theory to our own conduct, we profit thereby. Put on a smiling for a depressed and drooping face, speak in a cheerful instead of a miserable voice, and you feel better. The hysterical woman, on the contrary, who was doing very well until her doctor or her husband entered the room, now speaks as if she were nearly dead, and looks as ill as possible, in order to excite the sympathy upon which she lives, and the immediate result is that she feels ill, and, in fact, is ill in some degree. These, and a hundred other instances, show that sensations from the body do contribute notably and importantly to our emotional state; and for the clear perception of this we are all indebted to the authors of this celebrated theory, but no more can now be said of it.

The Probable Play of Sensations and Emotion Through an Emotional Centre in the Brain

The fact, no doubt, is that our emotions have a central seat, with contributions from the various parts of the body. No research into the functions of the *cortex cerebri* shows any trace of an emotional centre there. Nor need we be surprised, if we are at all prepared to believe the truth known to every lover of animals—that they have emotions like our own. The emotions must have their central seat in some old-established part of the brain. The Italian student Pagano has, in recent years, added much evidence in favour of the view that the "basal ganglia" of the brain, the great and ancient masses of nervous matter which occupy the base of the cerebrum, are the seats of the emotions.

And now we come to the simple but all-important question, What is the true relation of emotions, which are supposed to occur in man (because he knows he feels them), and instincts, which are supposed to be the peculiar characteristic of the lower animals?

Emotion the Subjective Aspect of an Instinctive Action

The truth, as Dr. McDougall was the first clearly to perceive and to prove, is that no such distinction as is commonly asserted exists at all. The facts are just the same in a man or in a dog. We can see inside ourselves, we have first-hand knowledge of our own consciousness, and introspection instantly detects what we call emotion there. We cannot see or feel the emotion of a dog; we only see its instinctive actions. As for our own actions, they are so largely modified

in character by our intelligence that their fundamentally instinctive character is commonly overlooked. Now, we have only to put two and two together. Man has emotion and instinct, and so has the dog. In both the emotion is simply the subjective, internal, psychological aspect of the objective, external, physiological performance or process which we call an instinctive action. But the two are really one and the same thing, with its double aspect, and henceforth they must be studied together, for they are inseparable, and neither can be understood without the other.

This theory of emotion as simply the "affective" or "feeling" side of instinct has now definitely superseded the James-Lange theory of emotion and all others. It was first briefly stated by Dr. McDougall in 1905, though, as he points out, Professor James and others came at times very near to it. Probably Dr. McDougall's advantage lay in his biological and medical training, which made it impossible for him to accept such distinctions between the fundamental facts of, say, man and the dog, as we have already quoted and repudiated. In very terse but complete form, the theory, as later defined by its author, runs as follows: "Each of the principal instincts conditions, then, some one kind of emotional excitement whose quality is specific or peculiar to it; and the emotional excitement of specific quality that is the affective aspect of the operation of any one of the principal instincts may be called a primary emotion."

THE SOLITARY MUD WASP INSTINCTIVELY PREPARING FOR ITS PROGENY

The test of a theory is its application, the number of facts which it sorts and explains and leads to the discovery of. Directly we apply this theory it works like magic. At once we can begin to form great pairs of instincts and emotions which largely dominate the life and constitute the mind of man—the instinct of flight and the emotion of fear, the instinct of repulsion and the emotion of disgust, the instinct of curiosity and the emotion of wonder, the instinct of pugnacity and the emotion of anger, the parental instinct and the tender emotion, and more besides. These are the real architects and constituents of man, of his behaviour, his institutions, and his societies.

He may call himself the reasoning creature, if he will, and, in so far as his intelligence is almost or quite his most distinctive characteristic, no doubt he is entitled to do so. But if he thinks that his intelligence moves him, is the spring, the motor of him, he talks nonsense. It is merely an instrument, used in the service of the instincts, just as habits are formed in their service. "Mankind is only a little bit reasonable, and to a great extent very unintelligently moved in quite unreasonable ways. By all means let us be moved in only reasonable ways, but, even so, reason is not the mover. In truth, men are moved by a variety of impulses whose nature has been determined through long ages of the evolutionary process without reference to the life of men in civilised societies."

The problem for mankind is not, as many Eugenists suppose, to get more "ability" into the world. [redacted] problem is [redacted] just [redacted] as [redacted] his [redacted] we call 'good' and [redacted] needs of social life and [redacted] and the restrictions the [redacted] and perhaps the losses which that implies. The tragedy of the world is not the lack of ability, which is [redacted], like dynamite, but the terrible [redacted], more serious than anything [redacted] Metchnikoff writes about under [redacted] name, between the various [redacted] any man, and only too often [redacted] upshot in conduct and the [redacted] of mankind at large.

If these [redacted] and colossal problems are ever [redacted]—which has been the task of [redacted] of religion and law, and custom [redacted] and government in all [redacted] must seek ever deeper and truer [redacted] of its factors within the [redacted] nature of man, and [redacted] closer study of the greatest of [redacted] that we must now proceed.

PATIENT MINISTERS TO MAN'S NEEDS

THE [illegible] THAT BLEAT FROM WOODY BOURNE—AFTER THE PAINTING BY C. E. JACQUE

THE OX WHICH GOETH TO THE SLAUGHTER—AFTER THE PAINTING BY LÉON BARILLOT

ANIMAL FLESH AS FOOD

An Impartial Survey of the Controversy Between Meat-Eaters and Vegetarians

THE HIGH VALUE OF VARIETY IN DIET

Now we come to a very old controversy which is still unclosed, and on which we shall take no extreme side. The question is whether or not we ought to use the flesh of animals as food. This question may be argued, and must in due season be argued, on moral grounds. Here we duly recognise them, and confine ourselves to the physiological controversy exclusively, and shall write as assuming, for convenience of argument, that that is the only question involved.

It is well to begin by noting that the word "vegetarianism," as commonly employed, is highly misleading. If there be those who live on nothing but vegetable diet, avoiding all food of animal origin, we shall ignore them here. But the food which makes and is made by cows is surely not a vegetable, nor are the very young chickens which we call eggs. After what we have said already in praise of milk, the reader will see that the arguments in favour of real vegetarianism are already condemned. Without the animal food called milk no human being can survive, and we cannot afford to deprive the adult of that unique food and its products. The herbivorous mammals, also, begin life on animal food; and the young of very many graminivorous birds are fed on insects i[illegible] their earlier days. It is well to be quite clea[illegible] about the common misuse of the wor[illegible] "vegetarian," and to confine ourselves to th[illegible] question of meat or no meat. Shall we [illegible] shall we not eat the flesh—that is, th[illegible] muscles—of any animals, whether fis[illegible] mammals, or birds?

Some delusions may be dealt with firs[illegible] There is no ground for the notion th[illegible] muscular tissue will specially serve t[illegible] muscular strength of the eater. The ve[illegible] tarian hippopotamus has nothing to le[illegible] from Sandow. But this view of diet [illegible] general is not unnatural, and occurs el[illegible]where. Thus it used to be thought that blood must be the best food for persons suffering from bloodlessness, but this is far from the truth, for blood is very indigestible by even the healthy, to say nothing of the anæmic, stomach. Then, again, blood being red, all red substances in general have been prized as serviceable for the making of the blood. Red wines have enjoyed a special reputation in this connection, though they have never done anything to earn it, and though nothing makes red blood like white milk. The red colouring matter of wine is totally different from the hæmoglobin of the blood, and actually has no food-value of any kind, whether for the blood or any other tissue. As regards red meat, the naive assumption is no better founded. The colouring matter of red meat is not hæmoglobin; if it were it would have to be broken up for purposes of digestion; and it would in the first place be destroyed by cooking. The substance which gives its colour to what we call butchers' meat is quite its least important constituent; and all theories which place red meat for strength above other meat, such as fish and chicken, are baseless.

Practically nothing is known regarding the relative values of meats of various kinds, [illegible]ept in so far as one may be more or less [illegible] than another. If we pretend to differen[illegible]te between beef and mutton, white meat [illegible]d red meat, one kind of game and another, [illegible]e have no scientific warrant, though, of [illegible]ourse, individuals have their preferences, [illegible]hich probably have good individual [illegible]arrant. Doubtless, also, different kinds of [illegible]uscular tissue have fibres of different size and length, which affect their digestibility, [illegible] the colour-test of food and drink in [illegible]eral is pure nonsense. As regards [illegible]estion, the large, coarse fibres of the [illegible]wly acting muscles of, say, a lobster are [illegible]urally much harder to digest than the

fine fibres of such rapidly acting muscles as those which move the wings of a bird.

The " Roast Beef of Old England " party may be quickly dealt with. " Beef, Beer, and Bosh " would be a convenient heading for a popular discussion of the subject; and if Dr. Johnson was right in saying that " He who drinks beer, thinks beer," it may be added, " He who eats beef, thinks beef," if he eats to excess. If " Old England " was founded upon any kind of food at all, that food upon which it floats was milk. " Ah, those English mothers ! " said Napoleon. After milk would come wheat. This belief in meat, under which term we may include all kinds of muscle used as food, is highly popular, and the simple explanation is that meat is a tasty food.

The Stimulation by Meat of the Nerves of Taste Evidence of its Suitability

The flavouring matters or " extractives " in meat, and especially in butchers' meat, have a very marked effect upon the nerves of taste, and the brown substance formed on the outside of the much-lauded " roast " is one of the [illegible]sely sapid of all known compounds. [illegible]e our palates to be tickled, preferr[illegible] insipid food; and thus the popular[illegible]ation of meat simply depend upon [illegible]t this food is as grateful to the sen[illegible]taste and smell, as it is. The ce[illegible] Russian physiologist Professor Pawlo[illegible] also showed that meat, or rather the flavo[illegible] juice of butchers' meat, has an uneq[illegible]d effect as a stimulant of the gastric juice. The popularity of a clear soup, highly flavoured with this juice, at the beginning of a dinner, is thus explained. But the usefulness of meat is a question untouched by [illegible]dence of the senses.

Perhaps that statement is too abs[illegible] The facts we have noted do at least fa[illegible] the view that muscular tissue is a natu[illegible] food for man. The unique stimulation of the nerves of the mouth and nose and stomach by its flavouring matters is strong presumption in favour of the view that the human body is well adapted, now, at any rate, for this diet.

Man a Natural Vegetarian Adapted by Habit to a Flesh Diet

The facts must once have been otherwise. Man is undoubtedly descended from a vegetarian, and the earliest forms of men may have been vegetarian, too; nor are man's teeth those of a flesh-eating animal. But he is very well adapted for the eating of flesh now; and there are those who say, probably without any real warrant, that the destiny of man was assured just when and because he took to what they regard as this much superior diet.

Yet not one of the substances which give meat its attractiveness to the senses is of the smallest food-value—except, of course, for its salts—and the actually nutritive constituent of muscular tissue, whether " flesh, fish, or fowl," is a white, tasteless, odourless substance, no more attractive to the senses than white of egg, which belongs to the same limited and distinctive chemical category of the proteins. No doubt the salts of muscle must not be forgotten; and it is worthy of note that vegetarian animals, as in America, are those which rush great distances, at times, to " salt-licks," whereas the carnivorous animals get salt enough in their diet of muscle.

But the chief and essential constituent of all muscular tissue whatever is simply its albumin or protein; and all the forms of this great food-staple are, in their pure state, as insipid, odourless, and free from colour as the typical albumin which we find, liquid or solid, in the white of a raw or cooked egg. Everything which really tempts us to eat meat has the whole of its functions described in that phrase. Apart from its stimulation of the gastric secretion, it would appear to be of no more value in itself than the jam in which a powder is concealed, and to play precisely the same part.

Experiments which Show that Beef Extracts have a Value Apart from Protein

Here, however, we must beware, for certain striking experiments have lately been made in Dublin which tend to show that, as we have already hinted, our cruder and older views of what is or is not a food require to be revised. Hitherto, we have measured the quantity, in any alleged food, of certain great constituents, like proteins, and have stated its food-value accordingly. Using this criterion, we have not been able to find much good in " beef extracts," or other similar " essences " of meat, for in point of fact these usually contain only the so-called " extractives " and salts of the meat, while the protein is excluded altogether. Now, in our category of foods these extractives have had no place hitherto, because we have roundly declared that a food must do one or both of two things, failing which it is not a food. It must either replace and form tissue or it must be a source of energy.

If it neither replaced tissue nor was a fuel, we had no place for it. However, there always were notorious exceptions to this

view, for common salt neither forms tissue nor can be burnt, but is necessary for life.

The Irish experiments have now been carefully repeated upon man, as well as upon dogs, which are admittedly carnivorous animals; and they seem to show that the use of certain beef extracts along with ordinary food, such as bread, tends markedly to increase its absorption. Very probably some constituents of the highly complicated mixture called beef extract may thus play a very useful part in nutrition. Other constituents are probably poisonous, if they are anything; and it will be one of the tasks for the future to analyse these extracts carefully, and find what parts of them are valuable, what neutral, and what objectionable, for it now seems that compounds of all these classes are to be found therein.

These Irish experiments compel us to recall and suspend judgment upon a great deal which has been written in former years on this subject, by the present writer among others. It is the fact, for instance, that animals fed on beef extract die of starvation as quickly as animals not fed at all. At first sight this seems conclusive—the extract has no food-value. But now we see that statement may be true, yet not true.

Meat Forced on Children Often Not Assimilated

A substance may be, in itself, incapable of sustaining life at all, yet it may be essential in enabling us to get hold of and utilise the substances by which life *is* sustained. Much hearty and apparently necessary condemnation of all beef extracts which are merely extracts, and contain no proteins, must therefore be reconsidered; and meanwhile the work done in Dublin constitutes the best argument that has been advanced for several years in favour of some measure of flesh in the food.

It is not, however, an argument which justifies us in trying to defy the appetite of those numerous children who dislike meat. A recent advertisement began as follows: "Many mothers experience considerable trouble with their children, owing to their dislike for meat, a fancy which, as a rule, only time will eradicate, persuasion being almost useless. Meat is such an essential part of a child's diet that if it be omitted on account of a little idiosyncrasy of the childish palate a serious loss of strength and vitality is likely to occur. On the other hand, food taken by a child under compulsion is seldom properly assimilated, and is little likely to be of any benefit."

Here the first and third sentences are correct indeed, but the second asserts what science cannot ratify. There is no reason to suppose that meat is an essential part of a child's diet. Probably only very little meat is the best for a child, and the so-called "idiosyncrasy" may be, for all we know, a wise provision of the child's body. It is probable, in especial, that the use of meat should not be encouraged in young people about the age of puberty. In early adolescence we should avoid stimulating food of all kinds, and to this category meat undoubtedly belongs.

The Scientific Distrust of Condiments Possibly Only a Half-Truth

These recent experiments are somewhat disconcerting in regard to the condemnation of condiments, in which most dietetic authorities agree. Certainly a child should have no need of condiments, nor should anyone else. We have already observed Nature's lack of provision in this respect when she sets out to make a food. Very many members of the well-to-do classes eat too much, or, at any rate, more than is safe and necessary. Condiments are simply a means of cheating their appetites to that end. But the fact already observed about salt, and what we now begin to learn about the extractives of muscle, suggest that we need to divide condiments into two classes. One class may be briefly defined as artificial or unnatural. Such are pepper and mustard, which do not occur naturally in any article of diet. Probably everyone would be better without their use.

On the other hand, it seems that we must recognise certain substances, undoubtedly condiments, which are natural ingredients of various articles of diet, and which may have special uses of their own, taking them out of the class of mere superfluities. This is certainly true of the indispensable condiment common salt; and now we see that it may be true of the condiments which naturally occur in most forms of muscular tissue. Further research may show that the distinction between these two classes of condiments is real and radical.

Meat Not Necessarily an Item in Anyone's Diet

Having tried to indicate justly the meaning of the Dublin experiments with meat extracts, we may continue with the observation that, quite apart from any humanitarian or ethical considerations, the consistent trend of dietetic and physiological inquiry for several years past has been against what we call the "Roast Beef

of Old England" party. At one time doctors roundly maintained that alcohol was an indispensable constituent of a healthy man's diet. No one now says so. Similarly, "butchers' meat" used to be regarded as necessary in a complete diet. No one now can say so. Meat is not a necessary item in anyone's diet; and probably most of those eat too much of it who can afford to—monetarily, that is, for no one can afford physiological excess.

Meat has been fairly tested, in a host of ways, both for physical and mental work. It is necessary for neither. Herbert Spencer tells us that he tried to do without meat for several months, and then had to destroy everything he had written during that period, owing to its lack of energy. This proves nothing for anyone but the experimenter; and it by no means follows that abstinence from flesh, beginning in childhood, would have robbed Herbert Spencer of any of his intellectual energy. Mr. Bernard Shaw, whose intellectual output never lacks energy, at any rate, and who is in that respect a match for most men, eats no meat.

The Effect of Porridge on the Development of the Thyroid Gland

A Scottish physiologist, Dr. Chalmers Watson, and others, have lately done some interesting work in Edinburgh, which is highly favourable, so far as it goes, to the views of the anti-flesh-food party. He has studied the value of porridge, which was until lately the staple food of the poorer people in Scotland, and the largely extending disuse of which coincides, at any rate, with our discovery of the appalling physical state of school children in Edinburgh. His research dealt with the influence of porridge on the development of the thyroid gland in the neck; and it entirely consorts with the modern view that we cannot merely reckon foods in terms of their protein and fat content, and so on. The thyroid gland is of the utmost importance. Its defective development gives rise to a well-marked form of idiocy, while defect of its function in later life produces a disease called myxœdema. Now, when large numbers of porridge-fed and meat-fed animals are compared, it is found that the thyroid glands of the porridge-fed animals are larger; and if the animals be killed and the glands "microscoped," we see at once that the glands of the porridge-fed animals are in a state of great activity. So far as this work goes, it looks as if oatmeal porridge, the celebrated staple of a great race, had a specific stimulant effect upon what is, perhaps, the most important of all glands for the proper development of the body.

But there is much more to say yet. Thus, we have reason to doubt the validity of the "uric-acid" argument against meat. This asserts that an excess of uric acid is present in the blood in gout and other disorders—hence classed as "uric-acid-æmia"—and that since, as is asserted, this uric acid must be derived from foods, such as meat, which are known to be sources of it, all such foods should be avoided. It may very well be true that the gouty man should be careful in diet, but the foregoing argument is not a good one, and must not lead us all to adopt a uric-acid-free diet, so-called.

The Untenability of the Argument that Meats Form Uric Acid Deposits

There is no reason to believe that the uric-acid deposit, in the joints and elsewhere, in gout, is a product of the food at all. It is the product of morbid changes in the tissues of the body; and there is no kind of proof that to withhold the foods which normally break down into uric acid is to correct the morbid chemistry of the living tissues. In any case, we all require what are called nucleo-proteins in our diet, to replace the waste of proteins in the nuclei of our living cells, and all nucleo-proteins yield uric acid in time. Lastly, where are the signs of gout or uric-acid-æmia in, say, the tiger, whose diet is such as to yield this acid in large quantites?

Such are the kinds of evidence, sometimes telling one way and sometimes another, which we must try to appraise. The provisional conclusion seems to be that, though meat is definitely not essential for the highest muscular or mental vigour, we cannot say, of knowledge, that the adult would be better without it altogether.

A Mixed Diet Best, with Meat Not More than Once a Day

That a mixed diet is best for man remains, perhaps, the only certain fact of dietetics so far as the choice of foods is concerned. But most prosperous people tend to eat too much, and meat offers special temptations in this respect, owing to its flavour and its effect upon the digestive juices. Further, it offers great opportunities to the cook, who is valued in proportion as he or she can succeed in cheating the appetite. At any rate, though more is by no means necessarily harmful, probably once a day is quite often enough to eat meat.

If it be granted that we may eat some meat, further questions arise. For instance,

;hould we cook it ? Some people will say 10: the " fire will destroy the vital prin-:iple," all food must be "unfired," and ;o forth. This means nothing to science, ›ut there may be something in the conten-·ion; and the something here is that meat s less digestible when cooked. This, how-:ver, is not precise enough. Cooking softens ınd loosens the connective tissue between .he muscle fibres, and so makes the meat nore digestible, but it hardens the protein of .he muscular tissue itself. Thus, the easiest :ourse for the digestive organs is to take neat as invalids sometimes do, raw, but vell chopped up, or actually grated. This ›rocess deals with the connective tissue, ınd replaces the effect of cooking. Ordi-iarily we cook meat, partly for æsthetic 'easons, partly through custom, and partly 'or its effect upon the connective tissue. 3ut also cooking has the very great advan-age of sterilising the meat, by killing any nicrobes that may be in it Often this may)e very useful, but oftener than not the neat really contains nothing dangerous. No food needs cooking for the sake of safety ıs our present milk does. Meat should)nly be cooked lightly, and it is much less digestible roasted than boiled.

The Expensiveness of Meat Compared with Good Vegetable Foods

All forms of meat, without exception, are 'elatively costly. In this respect, as in the ase of alcohol, prosperity may not be an ınmixed boon. Porridge is being largely eplaced by other things, such as bacon and)ther forms of meat, in Scotland; and ıccording to recent figures of the Board of Agriculture, in England we now consume .wice as much meat per head as twenty 'ears ago. The proportion of meat to)read has risen so much in consequence of ncreased prosperity. Whether the physique ınd the vital functions of men and women ıave prospered proportionately is quite ınother question, as to which we have just ·tudied some very disquieting *data*.

Muscular tissue is very much the same in 'ssentials, whatever its source. Fish has nany advantages as against meat. Having ess flavour, it is less likely to cheat the ıppetite. It is much cheaper, if we choose 'ightly. The variations in the price of fish ıave absolutely no relation to food-value. Here, as everywhere else, we pay simply for lavour. Reckoning by food-value, herring s the cheapest and best of all fish-foods. Fish have no special virtue for the brain or nental power, and do not contain any ex-:eptional degree of phosphorus, as popular opinion supposes. But the flesh of the fish furnishes as much vigour as any other kind of flesh. There is no lack of activity on the part of big fishes, which live on little ones. The most easily digested fish are those which contain least fat, such as cod, whiting, and haddock. This rule applies to meat also.

There is no ground whatever for superstitiously connecting the physical and psychical characters of the eater and what he eats, except where he eats grossly and to excess, and then the relation is accidental. The vegetarian does not become gentle, and the flesh-eater savage. The actual facts of natural history provide thousands of refutations of such ideas. It is not true that " man is what he eats." Rather does what he eats become what he is.

The Unfortunate Lack of Appreciation of Fish as a Food

These observations tend to show, when the dietetic habits of the people are examined, that we greatly underrate the value of fish. We do not at all appreciate " the harvest of the sea." Yet, as an island people, a seafaring people, a people crowded upon a finite island, and fed from without, we have every reason to value the harvest of the sea far more highly than we do. Sir James Crichton-Browne has lately done good service in calling the attention of the public to what students of diet know so well. Enterprise, science, industry, invention, can and must all be put into this matter, so that we may have a far larger and more secure supply of fish for our tables. The facts are that in the judgment of science we underrate fish as a food, though it has every title to stand beside butchers' meat, and probably has some special advantages of its own. We are really very foolish, judging fish by its relative cheapness and relative lack of flavour, but the deeper judgment of physiology returns a different verdict.

The Greater Digestibility of Meat Foods an Argument for Them

If we totally exclude all forms of flesh from the diet, we throw certain kinds of strain upon the digestive organs. Flesh is a concentrated food. On the whole, vegetable food is more difficult to digest, largely because the nutriment is hidden away in a quantity of innutritious matter, and has to be " got at," and also because it stimulates the digestive glands less strongly. To take extreme cases, we may compare the size of the abdomen of the cow with that of, say, the greyhound. The vegetarian tends to have a large abdomen, his diet being so bulky. He has to pay more in digestive

energy and in house-room, though his diet may be monetarily cheaper.

But there is much to be said for vegetable food, nevertheless. Man should certainly not be a pure carnivore, for he can live entirely without flesh. If the choice were necessary between a diet of flesh and a vegetable diet, we should have to choose the latter, because the various classes of food-stuffs are far better represented there than in muscular tissue, of which the strong point is the protein constituent. But the truth is universally applicable that "man cannot live by bread alone." He does very badly if he tries to live on protein to the exclusion of fats and carbohydrates, even though these are not absolutely essential. We must therefore include vegetables in our diet, and we must use our wits in order to avoid the necessity of having to spend so much time and digestive energy upon vegetable food as animal vegetarians do. They have a very long and complicated digestive apparatus, and their lives are almost wholly occupied in eating, digestion, and sleep.

But in the preparation of bread, and in the many devices lately invented by enthusiastic human vegetarians, we are learning how to get the value out of vegetable diet without having to pay too much life for it.

The Value of Vegetarianism in Helping the Appreciation of Vegetables

The vegetarian experimenters are thus serving us all, being led on by what is probably not a whole truth, to learn ways of dealing with vegetables which will be available for everybody, and will increase the variety and usefulness and pleasantness of the diet of future generations. How much there is to learn, and what results, in terms of health and disease, may depend thereon, the astonishing case of beri-beri, lately elucidated, suffices to show.

Animal and vegetable foods may be usefully compared under the separate headings of the customary food categories. So far as the supply of fat is concerned, there is not much to choose between them, except that vegetable fat is very much cheaper. This, however, applies especially to the case of butter. Other forms of animal fat do not compare so badly. Dripping, for instance, is a most cheap and valuable fat. Margarine must be highly praised. Modern margarine is made from excellent materials, it is very cheap, and is probably the equal of butter in every respect. The prejudice against it is deplorable. We prefer to pay, of course, for flavour, but the prejudice against margarine does not depend only upon our preference for the flavour of butter. It largely means that we suspect any food which is cheap, as in the case of fish. Hosts of our children—hundreds of thousands, certainly, and probably millions—are growing up with greater or less degrees of rickets, and other forms of malnutrition, who need more fat than they have, and who could have it safely and cheaply and pleasantly in margarine if it had ever occurred to those responsible for national education that you must first teach people how to live, and *then* what to do with their lives.

Flesh the Best Protein; but are Proteins Over-Valued?

As regards the carbohydrates, starch and sugar, vegetable food has the verdict, for no animal makes either of these substances for itself, and they are very useful fuel-foods. But as regards the proteins, flesh seems to be superior, for even wheat or pea flour is far inferior to even the fattest meat, not to say lean meat, on the score of protein. The question, then, comes to be, how much protein do we require? The very great superiority of muscular tissue in this respect gave it the place of honour so long as our ideas of our protein-need were maintained at a high figure. The older school of dietetics stated so high a figure that vegetarianism could not play up to it. But now come observers like Mr. Horace Fletcher and Professor Chittenden, to whose views we must return; and their advocacy of "low protein" suggests that the high proportion of protein in meat is a burden rather than an advantage. The trend of opinion is well indicated in the following quotation from the revised edition of Dr. Robert Hutchison's standard work on "Food and the Principles of Dietetics." Both as regards protein and alcohol, the author has a very decided leaning towards the old school, like Sir James Crichton-Browne. And this is what Dr. Hutchison now says.

The Ideal—a Moderate Quantity of Many Foods

"The danger, indeed, is all the other way, in the direction of a too-liberal consumption of meat. It is for insisting upon the disadvantages of such a course, and on the feasibility of living upon a diet from which meat is altogether excluded, that we in this country owe even the extremist vegetarian a considerable debt of gratitude; and if the above objections to living upon a minimum of protein can

be shown to be groundless, as the experiments of Chittenden have already done something to prove, then the objections to a purely vegetarian diet largely disappear also."

Here Dr. Hutchison uses the words "purely vegetarian" in the loose sense which means "without flesh."

The new school of dietetics has so much to teach us, and has so many ardent adherents, that we shall have to deal with it and some of its rivals in a succeeding chapter. Meanwhile our somewhat confusing and contradictory study of the pros and cons of meat must be valued for what it really teaches. We have already laid down two great propositions, which are that moderation and variety are fundamental for the best diet. We may live without moderation, and upon a very limited range of food-stuffs, but the ideal is a moderate quantity of many things. The human body is the highest, most complicated, most adaptable, most various in its aptitudes, of all living things. We may reasonably suppose that it therefore does best with a proportionately varied diet. This presumption agrees with the evidence here submitted in disposing of the extremist of all parties. The probability is that we do best by including a little muscle, along with a host of other things, in our daily diet.

The Wants of the Body so Many that Only Variety Can Meet Them

This is not what the "Roast Beef of Old England" party declares, nor what is preached by Mr. Eustace Miles or by Dr. Alexander Haig. The scientific evidence, which seems to be so contradictory, for and against, as we pass from Dublin to Edinburgh, and so on, is really not contradictory at all. It agrees with itself in showing that any marked bias in a diet is deleterious, depriving us of some advantages and incurring special penalties. For sheer nutritive success nothing seems to beat the mixture of cereals and beef extract which was tried in Dublin, and these two are fairly well at the extremes of diet. If we go further, and ask of a diet not only that it shall sustain life and maintain the body-weight, but also that it shall promote the development of all the glands of the body, and that it shall be inimical to the development of disease, we shall find these reasonable demands so exacting that only much variety can meet them. Many diseases—infections from without, such as tuberculosis; morbid processes from within, like scurvy; and defects of development, like cretin idiocy—have close relations to diet. The future will define them precisely. Meanwhile the evidence is clear. Not only do we need "proteins, fats, carbohydrates, salts, and water," but we also need a long list—it may comprise hundreds of items, for all we know—of special substances, which only a widely varied diet can be trusted to supply.

The normal appetite of a boy may be fairly well trusted. He is usually game for anything that is "good to eat." He likes meat and mushrooms, goose and grapes, cauliflower and chocolate, toast and salted almonds, and he probably gets some good out of everything he swallows.

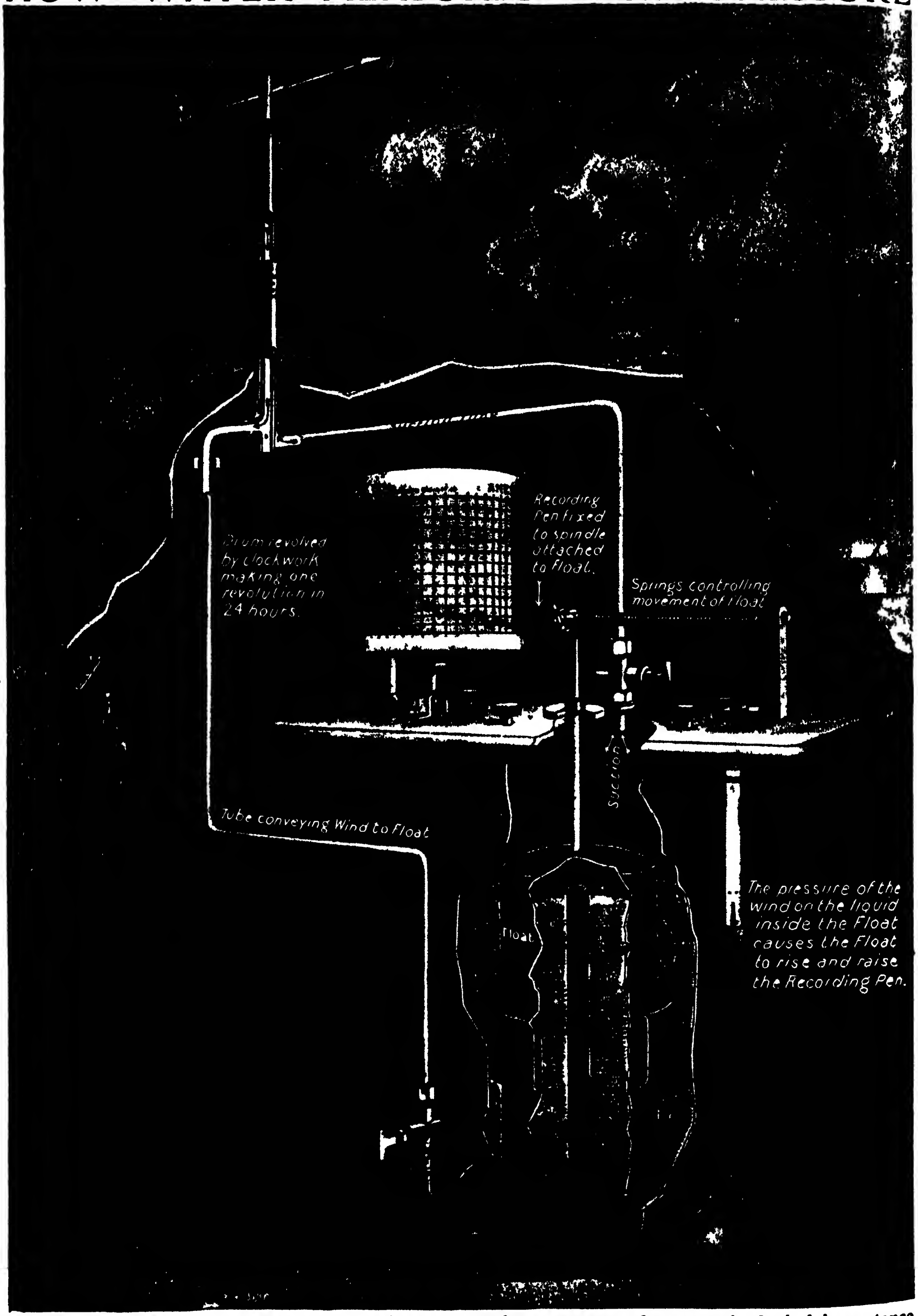
The Danger of Some Things Being Eaten to Excess when Few Things are Eaten

Further, if this demand for variety be properly understood, we shall see that it helps the other demand for moderation. Limit the diet, and, in order to get enough of one thing, we may have to consume too much of another. This is compulsory excess. Vary the diet widely, and nothing will need to be taken to excess. If this is a wise counsel for adults, who have only to maintain their bodies, it is wiser still for children and adolescents, whose bodies are developing. Let us remember the action of porridge upon the developing thyroid gland in Dr. Chalmers Watson's experiments—an action which no one suspected until the other day, but which goes right down to the roots of mental and physical health. Beware, then, of restricting the diet of anyone, in terms of quality, for wide and free variety, which will include muscle, on equal terms with other things, must conduce to the ideal in which the organism, guided by a free and natural appetite, gets enough of everything and too much of nothing.

All Forms of One-Sided Diet a Physiological Mistake

The more closely we survey the theories and practice of the food faddists and doctrinaires, the more clearly we may see that, one and all, they are in a state of extreme reaction against some extreme and one-sided diet—whether "chops and steaks and porter," or "nuts and raisins," or what you will. Reverently to adapt even to the physical—which is a symbol of higher things—words spoken of such things, we find ourselves, in the twentieth century, in the act of proving, by laboratory experiment, the ancient words: "Man shall not live by bread alone, but by every word that proceedeth out of the mouth of God."

HOW WATER MEASURES WIND PRESSURE



The new science of aviation has made the knowledge of the motion of the wind of vital importance to men. This diagram shows the principle of the anemo-biagraph, an instrument which records on a clockwork drum the intensity of gusts and lulls in wind, an accurate record of what is called its "structure," and its correct mean velocity at any time. The pressure and suction effects of the wind acting down two tubes upon a float give a perfectly true record, the two tubes being necessary to eliminate casual alterations of pressure in the room in which the recorder is placed.

MODERN WEATHER WISDOM

The Difficulties and Problems of
Tracking Storms Across the Oceans

HOW LABRADOR BREEDS TEMPESTS FOR US

It is scarcely more than a hundred years since Napoleon was at the height of his power, looking for new worlds to conquer. For various reasons he fixed on Russia as the scene of his next triumph; and, to make sure of the success of his campaign, he asked Laplace, the greatest French man of science of the age, to forecast the weather likely to be experienced in a Russian winter. Laplace did his work quite as well as was possible. He collected information, extending over a long series of years, and arrived at the generally sound conclusion that the period of extreme cold did not begin in Russia until January. So Napoleon made his plans accordingly, but a sharp spell of cold occurred in December, with the result that the Grand Army was lost. The magnificent fabric of power that Napoleon built up was thus suddenly destroyed by an incorrect weather forecast.

The fact is that the method employed by Laplace can never give a trustworthy result. No matter how full are the statistics of the variations of heat and cold, rainfall and dryness, air pressure and wind, and no matter how carefully the calculations are made of the average kind of weather of each period of the year, no dependence can be placed on the general probabilities so arrived at. Averages of this sort throw a good deal of light on the climate of a country, but they afford no guide to the actual weather that will occur. Of course, a mass of sound information concerning the climate of a place may be very useful in other ways.

Statistics of the annual amount of rainfall are often of commercial value, as bearing on the question of economic supply of water for large towns. And seaside resorts often succeed in attracting profitable visitors by publishing the annual amount of sunshine registered by recording instruments. But all the large masses of figures that have been accumulated by the statistical method are of little or no value in an attempt to predict the daily or weekly changes of weather conditions. For these conditions are shaped by an incalculable variety of forces which are sometimes set in a different working order almost by chance.

The weather from day to day depends upon factors so variable and unstable that a forecast beyond an hour or two is unsafe in many cases by ordinary methods. A striking illustration of the difficulty of making a forecast was given some time ago by Professor Balfour Stewart. Suppose there is just above us a layer of air that is very nearly saturated with watery vapour. It is just a little above the dew-point, but at the same time it is losing heat rather slowly. If this layer of air were left to itself, it would be a long time before it deposited moisture. Yet it is in so delicate a state of balance that the dropping into it of a small crystal of snow would at once cause a remarkable change. The snow would cool the air around it, and moisture would be formed about the snowflake in the shape of fine mist or dew. This deposited mist or dew would yield up its heat more rapidly than the saturated air. So it would become colder than the atmosphere around it. Thus more air would be cooled, and more mist or dew deposited, and the process would go on until an entire change of weather conditions had been brought about.

The tiniest possible flake of snow, in a case of this sort, would, so to speak, pull the trigger and make the gun go off. It would alter completely an arrangement of weather conditions that might have continued for some time longer, and perhaps

been given at last an entirely different complexion by the advent of, say, a warm upper wind. We thus see how in our atmosphere the presence of a condensible liquid adds an element of violence, and also of abruptness, to the motions which take place. The movements of the air that sweep from the equator to the Poles are so diversified by local conditions that their course can seldom be predicted. Added to this factor of difficulty, there is the mighty volume of evaporated water carried above the world, and condensing and altering the temperature and producing sudden changes in the movements of the air. Our knowledge of weather conditions cannot, therefore, ever be scientifically complete, like our knowledge of planetary motions. For there exists an element of instability, and consequently of incalculability, in virtue of which a very considerable change may result from a very small cause.

It is quite possible that large and fairly regular periods of weather occur. Indeed, a small but eager band of men of science has for a long time been trying to ascertain and establish the laws of these recurring periods. Several astronomers have endeavoured to connect the recurrence of dark spots in the sun with weather disturbances occasioned by changes in the amount of the electro-magnetic force acting on the earth. The sun-spots have a period of about eleven years; but in studying the rainfall records it is found that, although they have coincided to some extent with the sun-spot cycle, especially during the last century, they show large variations on a smaller scale. And even in trying to measure and determine this smaller scale the most learned men who have tackled the problem disagree in their results. Professor Schuster, for example, finds a rainfall cycle of 4 years 289 days, while Sir Norman Lockyer and Dr. W. J. S. Lockyer assign a period of $3\frac{1}{2}$ years to the oscillations.

THE SWISS WEATHER HOUSE BAROMETER

The figures are so arranged that as the air becomes damp the man comes out of the door and the woman retires, and when the air is dry the woman comes out and the man retires. This is effected by attachments of cat gut sensitive to moisture.

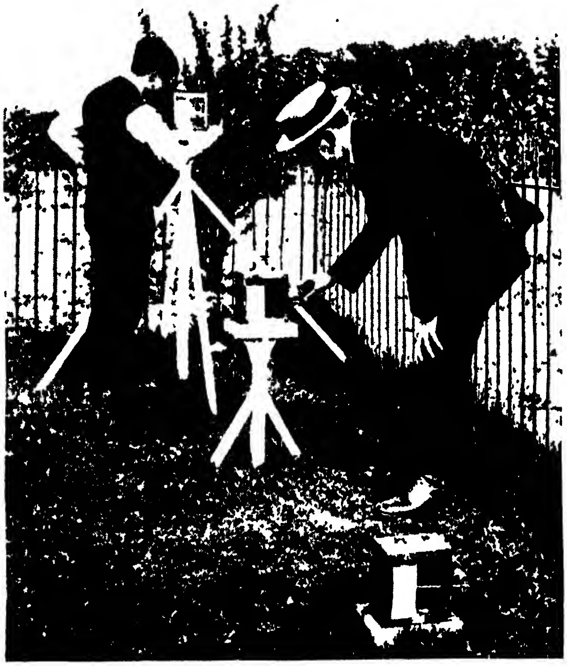
The most famous of all these attempts to foretell the character of the weather over long periods was that made by Professor Brückner, of Berne, in 1890. He brought together all available records of the sequence of rainfall, heights of rivers, levels of lakes, and other information connected with the fluctuations between dry and rainy times. And from all this intricate mass of evidence he concluded that a variation of rainfall recurred in an average period of thirty-five years in Europe. By a similar method of calculation Mr. H. C. Russell, of Sydney, has traced a period of nineteen years for the variation of the rainfall of Australia. Dr. Lockyer has confirmed this calculation, and found that it also applies to South Africa. Colonel Rawson also agrees, after much study, with the nineteen years' period in the case of South Africa.

No farmer, however, dares to rely on any of these calculations in arranging what crops he shall plant for the coming year. For though the periods of recurrence can be traced when records for long intervals are studied together, the average result is apt to be illusory as a guide to the amount of rain and sunshine in any particular year in the future. As a matter of fact, there is a well marked seasonal variation in the rainfall of our own country. October is the rainiest month in a part of Great Britain, and March the driest. Yet if we were to hazard the prediction that next October would be the rainiest month in the year it might turn out to be a complete exception to the general rule, just as the August of 1912 disappointed the common and well-founded expectation of warm, sunshiny, settled weather. As a rule, only the east of England has its rainiest period in July or August

Yet in spite of all the difficulties that prevent mankind from foretelling the weather only a few days ahead, attempts have been made for five thousand years and

more to forecast changes from cold to heat and from raininess to fineness. Stonehenge—that strange monument of the Stone Age—was probably in its origin partly a vast instrument for weather predictions. It was an astronomical observatory, by means of which the wizard priests of our savage predecessors were able to tell, by the course of certain stars that came in line with one of the stones, the recurrence of the seasons. To the rude farmer of the New Stone Age, who had no means of measuring the lapse of time, it no doubt seemed wonderful that the return of the warm weather could be foretold by the star-gazing wizards.

Very likely the value the stars had in indicating the return of the seasons was mistaken for an actual power in bringing about changes in the weather. And from this it was concluded that the heavenly bodies exercised as large a control over human life as they apparently did over the seasons of the earth. Thus arose directly out of the primitive method of weather forecasting the superstitions of astrology. Some of these ancient superstitions still form part of the common weather lore of civilised countries. Many persons, for instance, still think that a spell of wind and rain will not be broken until the moon changes.



READING TEMPERATURES AT DIFFERENT LEVELS BY MEANS OF SELF-RECORDING INSTRUMENTS

Well-educated persons, who believe in this strange and powerful lunar influence, try to find a ground for it in the theory that the moon produces tides in the air just as it creates tides in the sea. But why it should do this only when the amount of light reflected from it changes to our view, while its mass and gravitation power remain constant, is something they do not attempt to explain. At a matter of fact, the changes in the light of the moon have nothing whatever to do with the changes in the weather. Full and minute records of weather changes and lunar phases have been compared again and again with the utmost care, but no active connection has been traced. The whole thing is simply a vestige of the ancient widespread superstitions of astrology.

On the other hand, there is a good deal in the traditional weather lore of all the races of the earth which is based upon sound observation. Experienced sailors and farmers can often tell when a storm is approaching. The look of the sky, and particularly the forms of the clouds, are indications of weather conditions. All over the world haloes round the sun or swallows flying low are known to be signs of rain. And a copious fall of dew or a white, silvery moon are equally widely recognised as precursors of fine weather. One of the earliest collections of weather lore is found in the "Diosemia" of Aratus, a Greek who flourished in Macedonia and Asia Minor about 170 B.C.

The principal interest attaching to his work is that many of his prognostics were incorporated by Virgil in his Georgics, and that from them through the medium of the Latin monks, during the revival of learning in the Middle Ages—a very considerable number were translated into modern European languages, and are in current use at the present time. From classic times down to the beginning of the nineteenth century, scarcely any advance was made in this branch of weather science. Few, if any, new indications of change had been discovered, and no scientific explanation could be given of the reasons for the popular traditions.

Man had invented the steam-engine, the railway, and the steamship; he had

discovered the laws of the subtle force that keeps the planets circling round the sun; he was well on his way to make his own lightning and set it to drive his machines and light his streets and dwelling-places, and flash his messages across the world. Yet, in spite of all this wonderful advance in knowledge and power, he had no more skill in forecasting the weather from day to day than men possessed two thousand years before. In most cases it was only when the front of a storm was upon him that he could tell that the rainclouds in the rear of the atmospheric disturbance would soon fall, with more or less wind. There was time to shorten the sails of a ship, but seldom time enough to put off a farming operation.

It was first thought that the invention of the barometer would add to man's power in forecasting the immediate weather. To some extent this is the case. When the barometer rises it sometimes foretells less wind or a less watery sky; and when it falls it sometimes indicates wet weather or more wind. But the trouble is that it rather frequently rains or grows windy with a rising barometer, and occasionally becomes drier or calmer when the glass is falling. So the barometer only added at first to the complexities of the weather problem.

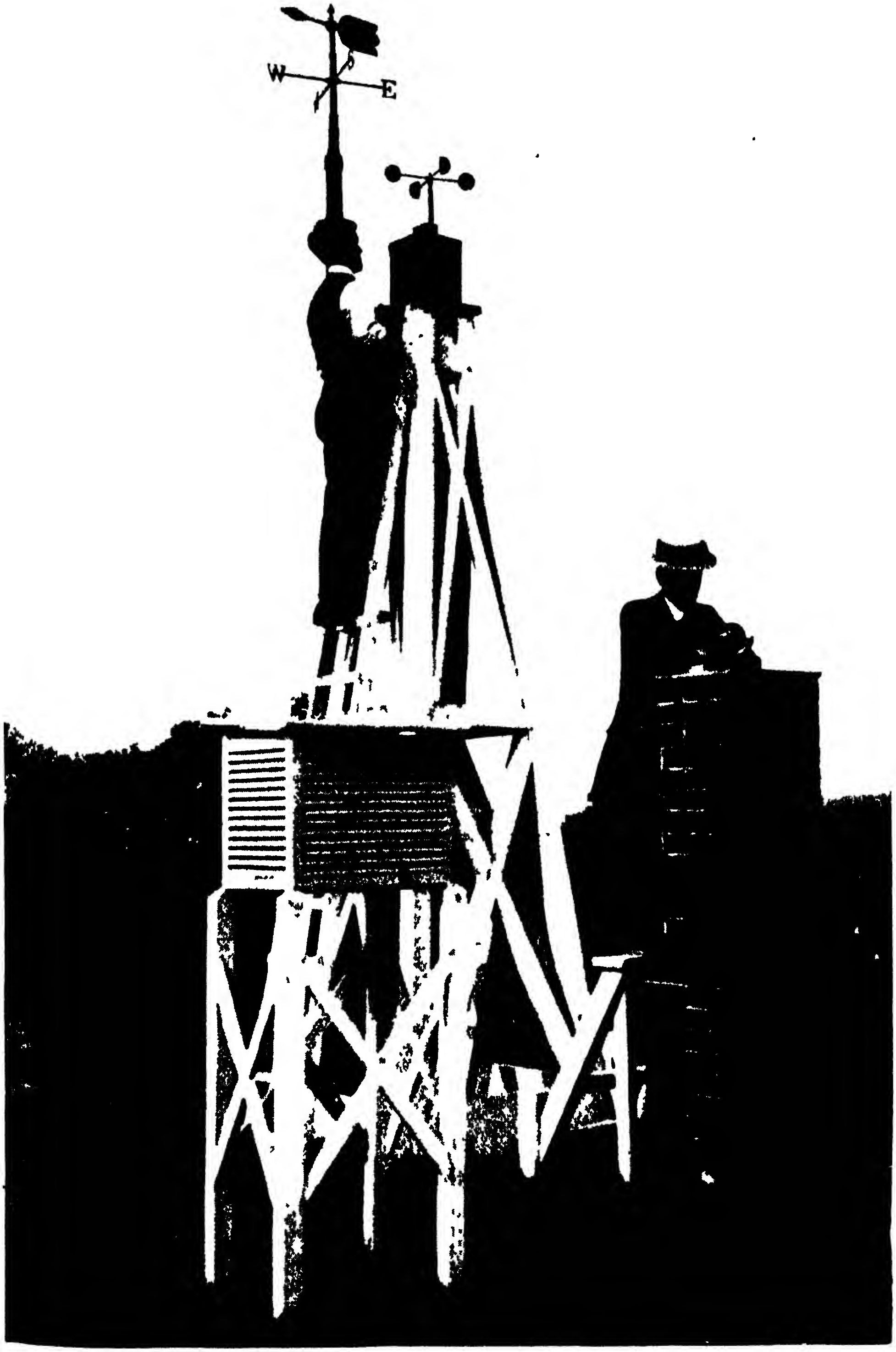

SUN-THERMOMETERS

As has already been explained in POPULAR SCIENCE, the column of mercury in a barometer just balances the normal pressure of the atmosphere of the earth. The rising and falling of the heavy fluid in the tube merely shows that the air has grown more rarefied or more dense above the spot at which the barometer is placed. Only indirectly are the variations in the pressure of the air indicative of coming changes in the weather conditions. A considerable amount of skill is needed in an observer who, single-handed, tries to forecast rains and winds by means of his solitary barometer. He requires a sound knowledge of the local circumstances that affect changes in the weather, and he must supplement his study of barometer readings by the kind of cloud-lore that a sailor or farmer of the old school possesses. And with all this he is liable at times to make gross mistakes, specially when he attempts a prediction of some hours in advance.

The movements of the ocean of air surrounding our globe might be compared to the motions of a river. A river forms descending eddies or whirlpools in some places, and in other spots backwaters in which the water is rising upwards. By taking a survey at many points of the stream, it is easy to trace where the water is rising in a stagnant backwater, and where it is descending in an agitated eddy. So the general movements of the river may be studied; and even if the whirlpools are shifting it will be easy to calculate their course.

But supposing, now, that the observer were at the bottom of the river, with merely a single instrument for determining the pressure of the water. He could at times make out, from the fall in the pressure recorded on his instrument, that a whirlpool was at hand. Or if the pressure was more than usual, he would know that the waters were banked up above him. But from his single instrument he could tell nothing about the general movement of the coursing eddies of low pressure, and the more motionless stretches of banked-up and heavier waters. This is somewhat the position of a solitary observer at the bottom of the vast, broad stream of air. He can sometimes tell by the changing pressure that a storm-eddy is veering towards him, but he cannot discern its course and its speed, and so warn people fifty miles or more away that it will probably reach them in a given time.

All this began to be seen in the United States in 1837. And the invention of the telegraph inspired some men of science with the idea of collecting at central stations a series of simultaneous observations made and sent from different parts of the country. The idea was to map the ocean of air over the settled portions of the United States into a series of observing-stations. In this way all the descending eddies and rising backwaters of the atmosphere could be plotted out on a general chart of the country, thus combining the scattered information of an army of observers. So, while each observer would still remain blind to everything that was not happening in the air directly over his head, yet the little bit of information he sent to the central office would help to



Taking the direction and velocity of the wind, and recording the duration of sunshine at a meteorological station in the Royal Horticultural Society's Gardens at Wesley. The reading of the weather that has been is a step towards reading the weather that will be.

build up an illuminating map of the conditions of the atmosphere. It took some time for the Americans to grasp the fact that a map of this sort would have a value far exceeding that of the scrap of information each observer obtained for himself. And it was about ten years after the idea of the weather chart was formed that Commodore Maury, famous for his study of storms, took up the matter, and strongly advocated the establishment of a central weather office. And in the early 'fifties the plan was put into operation by the great American man of science Professor Henry, who distinguished himself in the study of electricity. Thus the United States won the honourable position of pioneer in weather science, and gave the rest of the civilised world an example of high importance. Unfortunately, the outbreak of civil war between the Southern and Northern States disorganised both the telegraphic communications and the lives of many of the scattered observers, and the charting of the weather had therefore to be discontinued.

A THEODOLITE FOR DETERMINING THE HEIGHT OF CLOUDS

But in 1853 Maury had visited England, with the aim of arousing public attention to the value of weather science; and he was so successful that a meteorological department was formed at the Board of Trade in 1855. Barometric stations were established, from the Shetland to the Channel Islands, the Government providing the instruments, helped by private persons and the Meteorological Society. Then in 1861 the example of the United States was followed, and telegraphic communications were established between widely separated stations and the central office in London. In this way a means of feeling—or rather of mentally seeing—the succession of simultaneous conditions of the atmosphere over Great Britain was obtained, and it then became possible to make a series of regular charts from which a forecast could be drawn.

Our first clerk of the weather, Admiral FitzRoy issued his first warning of a storm in February, 1861; and in August of the same year the first general forecast of our changeable weather was published by him. All he had to work on were twenty-two morning reports and ten afternoon reports, together with five reports from the Continent. Yet, greatly daring, he issued on this slender information a forecast for two days in advance. Eight daily papers, one weekly journal, and Lloyd's, the Admiralty, the War Office, and the Board of Trade received the forecast with all the information on which it was based.

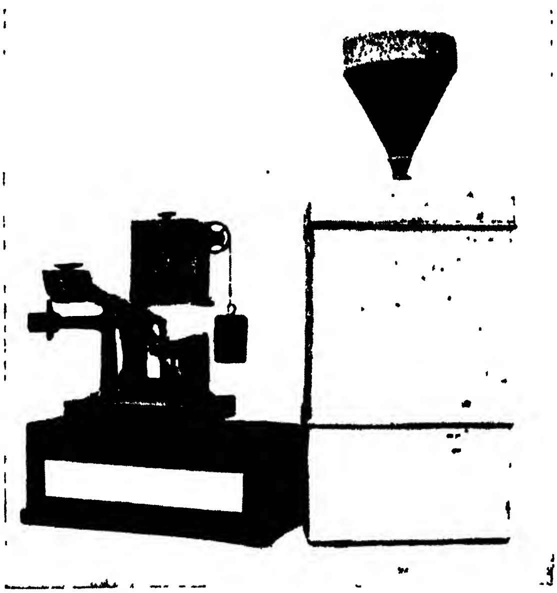
Soon after Admiral FitzRoy had succeeded in convincing our nation of the value of charting a series of simultaneous observations, and drawing a general conclusion therefrom for daily use, the famous French astronomer Leverrier induced his Government to establish a national weather office, which quickly became the centre of an international system of daily forecasting. In spite of the scanty reports on which the directors of British and Continental Meteorological Offices had first to work, and in spite of the fact that the principal laws of the weather were not then clearly understood, the forecasts were sufficiently successful to win for the newly born science the favour and interest of the public. So the various organisations increased in number and in scope; and out of their imperfect but hopeful labours a discovery was at last made which greatly extended the prophetic powers of the chart-makers.

As is well known, a weather chart is constructed by taking an outline map of the country, and marking thereon the observing stations and the height at which stands the column of mercury in each barometer. When the stations are sufficiently numerous to cover with small intervals an entire country of considerable extent, a curiously informative map of the air can be made, by drawing lines connecting each station at which the same air-pressure simultaneously occurs. Suppose, for instance, that all the inland stations of central England dispatched telegrams reporting that their barometers stood at

$29\frac{6}{10}$ inches, while the stations outside reported higher readings—say, 30 inches. In this case, when all the figures were plotted in the chart, with lines drawn between those of the same value, there would clearly be seen, in the Midlands, a large oval depression of rarefied air, surrounded by curving banks of air at high pressure. In this case the chart-maker could tell, without glancing at the information about the amount of rain, wind, and cloud contained in the reports of his correspondents, that the oval-shaped island of light air was a storm-centre. And as each successive telegraphic report was received by him and plotted out on a fresh map, he could watch the island of light air as it travelled through England; he could calculate its speed, by comparing its position on the various charts, and so warn the places towards which it was travelling of the bad weather that was sweeping towards them.

These islands of depression are the easiest material with which the forecaster has to deal. For they form a type of weather of which he knows pretty well the whole character and laws. In front of the depression there is a thin layer of cloud, that gives a watery look to the sun and a pale appearance to the moon. If there are any hills ahead, these have a cloud-cap upon them—hence so many local sayings about hills putting on their hoods or caps when a storm is coming. As the island of air extends over a district, the atmosphere grows close and muggy. Persons suffering from neuralgia or rheumatism, corns and wounds, feel the shooting pains that make them weather indicators. Many animals become restless, and birds fly close to the ground; and if the disturbance is travelling very quickly a drizzle of rain is soon felt. This is followed by a driving rain. After a while, patches of blue appear in the sky, squalls or clearing showers sweep over the country, then the storm passes away, leaving a blue sky behind it.

The forecaster can often foretell that all this weather is happening merely by seeing on his map the oval outline of a low depression, with masses of air of a higher pressure surrounding it. He even knows the direction the wind will blow in such a storm. It was, in fact, by studying the wind in conjunction with the different barometer readings between the island depression and the surrounding masses of heavier air that a famous Belgian man of science effected the first and most important step in transforming weather forecasting from a haphazard art into something like a science. For he found that the wind rotated with a cyclonic movement about the centre of the depression, and he came to the sound conclusion that storms of this kind were real cyclones, such as occur with greater intensity in many other parts of the world.



A SELF-RECORDING RAIN-GAUGE

To the right is the rain-receiving funnel, and the case of the instrument, which is shown on the left. This consists of a cup that automatically empties itself when full, recording its contents on a clockwork drum.

A tropical hurricane has been traced travelling from the West Indies to Britain, losing its intensity as it went, and arriving at our shores in a very mild form.

In contrast with the cyclonic systems of low depressions of the air, there are the regions of high pressure that often bring fine weather. These are called anti-cyclones. They are mapped out on the chart by connecting all the neighbouring points from which are received telegraphic reports that the barometer stands at 30 inches, more or less. By drawing lines between these high points, the chart-maker gets a curve that tells him roughly the shape and situation of the system of atmosphere conditions that make for fine weather. But though an anti-cyclone is, as a rule, fine, quiet, and dry, it is often, in winter, the cause of fogs and intense frosts. For the

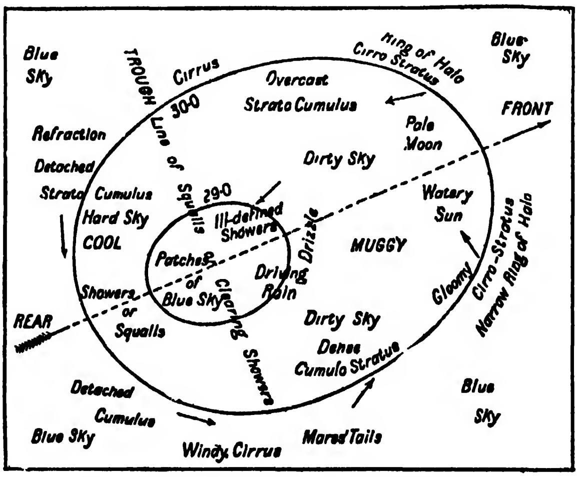
cloudless sky that it brings promotes the radiation of heat from the earth.

Generally speaking, all our very cold weather is home-brewed. That is to say, it is not icy winds from the plains of Europe or the heights of Norway that bring us low temperatures of an extreme kind. A dry, calm island of air of high pressure often forms in our Midlands, producing great coldness there, while, in places nearer to the eastern and western seas, the air is fairly warm for the time of the year. The explanation is that a clear, calm sky, with no water-vapour in the atmosphere, results in the earth radiating its heat into space. So the air grows cold by contact with a chilly soil. Siberia, for instance, is extremely cold in winter, because the weather is persistently clear and fine there.

So we cannot say that an anti-cyclone is always desirable in winter time, for it produces a great amount of fog, that blankets the earth for days, and makes London especially a region of gloomy horror. What the Londoner then longs for, without usually knowing the science of his desire, is the long curve of falling barometer readings, sent by wireless from Atlantic steamers, and then reported by ordinary telegraph from the observing stations on the western coast of Ireland. For such a long curve of falling figures means that a cyclone of vast dimensions is sweeping in from the Atlantic. Just about the time that it is impending its front over Ireland, signs of its coming may be read on the sky at Folkestone. The midnight moon loses her brilliance, and the sun is dimmed by the vapour gathering in the moist, warmer air of the cyclone front.

The forecaster, however, has first to look at reports from the Continent before he can venture to say that the fog and frost will be swept away by the coming storm. Perhaps an immense anti-cyclone covers the whole of middle Europe, and is advancing its head from France, and connecting with smaller islands of dense air over the Baltic. In this case it may also link up with the foggy anti-cyclone over England, with the result that the eddying storm from the Atlantic will be forced sideways towards Norway. A good deal of judgment, born of long experience and close study of the meaning of the curves of air-pressure shown on a general chart, is necessary to enable the weather forecaster to do his work well.

And, as a matter of fact, the charts that our director of meteorology uses in his calculations—eleven hundred of them are drawn by his assistants every year—are seldom confined to the simple plotting of cyclones and anti-cyclones. The lines of pressure recorded by the barometers of the observing stations take a variety of forms. Besides the two oval-shaped islands of low pressure and high pressure, there often run secondary curves looped around a cyclone. And very common are the tongue-like outlines of depression that are called V-shaped depressions.



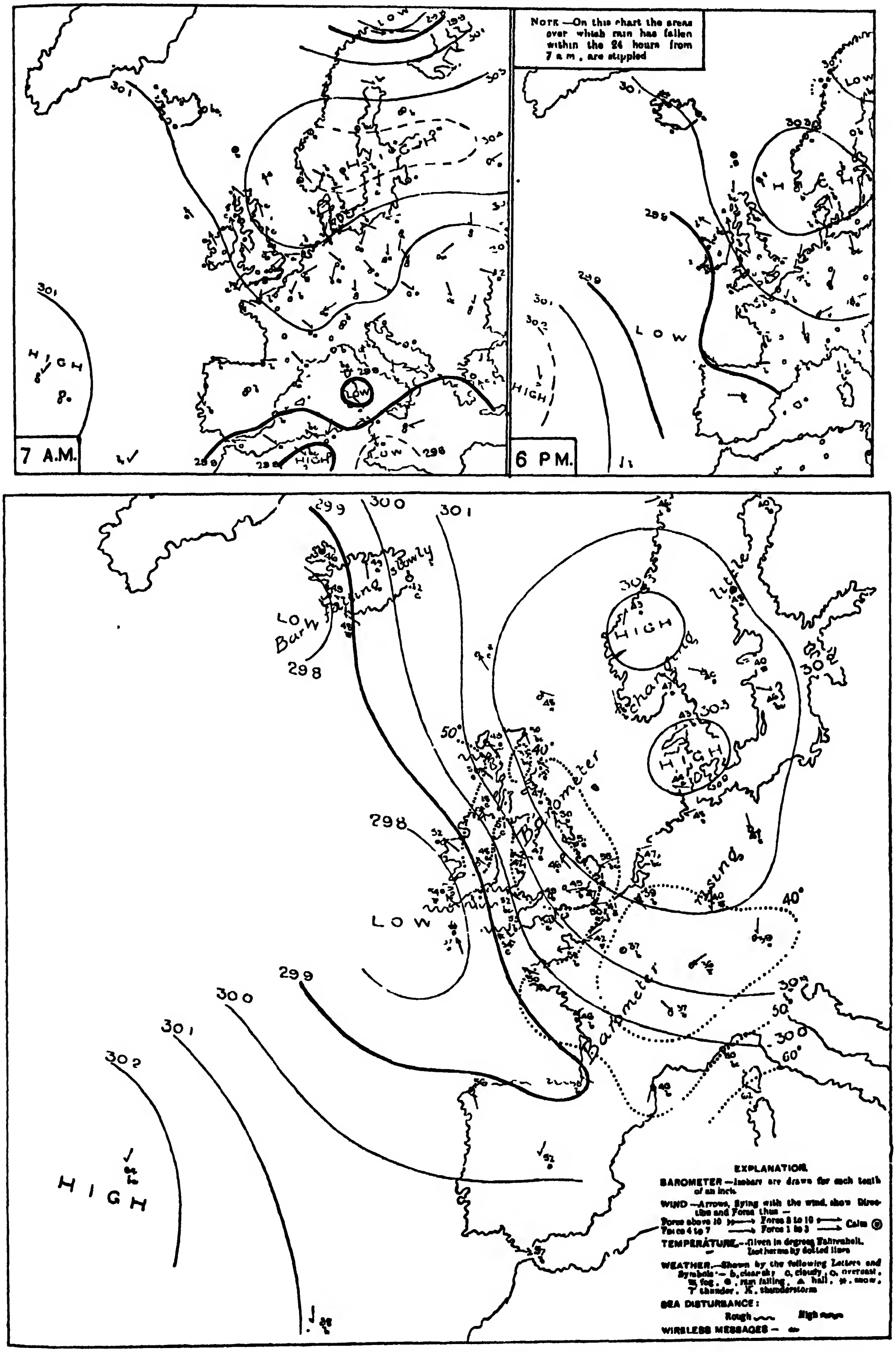
THE WEATHER OF A TYPICAL CYCLONE
(After Abercromby and Marriott--from the Quarterly Journal of the Meteorological Society)

Then there are tongues of high pressure, one of which is sometimes inserted like a wedge between two areas of low pressure. These are called wedges, to distinguish them from the V-depression.

Again, the lines of air-pressure may be straight, lying across a country, and mapping it into descending steps of atmospheric density. Lastly, two anti-cyclones may be connected with each other by means of a furrow or neck of relatively low pressure of atmosphere. This system of weather conditions is called a col, because it has some analogy to the col or neck that forms a pass between two neighbouring mountain peaks. There are thus two primary types of air-pressure outlines, and five secondary shapes. It is these secondary shapes that generally give the forecaster most trouble.

In V-shaped depressions violent shifts of wind and sudden changes of temperature usually occur. And they are accompanied by heavy squalls, with showers of rain and hail, or winter's snow. They are the birth-

THE COMING AND GOING OF THE WEATHER



A TWENTY-FOUR HOURS' RECORD OF WEATHER-DRIFT FROM MID-ATLANTIC TO BALTIC

A specimen of a daily chart prepared by the British Meteorological Office

place of many thunderstorms, as also are the secondary depressions. Very slight differences in the curves of these outlines of low pressure are sometimes indicative of abrupt weather changes. And the considerable amount of the progress that is being now made in forecasting seems to depend on the subtle interpretation of almost unnoticed variations in the lines plotted out, in hundredths of an inch, on barometer charts. And here there tells also the information as to the force and direction of the wind, and the temperature and the state of the sky, which the forecaster receives from each observing station.

Our own Meteorological Office publishes two forecasts daily, and achieves in every hundred forecasts ninety partial successes and sixty complete successes. Taking all things into consideration, this is a remarkable feat. For the circumstances in which the forecasts are made are much more intricate and obscure than those against which the Weather Bureau of the United States has to contend. The American weather forecaster, who is famous for his successes, has an immense land area, which he is able constantly to study by telegraphic reports streaming in to him from all sides. He can track his storms across a continent. The British clerk of the weather, on the other hand, stands practically on the shore of the Atlantic Ocean, with, north-west of him, unknown movements of air in the Arctic waste that are liable to introduce unforeseen factors into his calculations. Indeed, it is only since an observing station at Iceland was put into daily communication with London that our weather charts were drawn up in a proper manner.

THE EXPLORATION OF WEATHER CONDITIONS IN THE UPPER AIR

Liberating a small balloon with parachute and meteorological instruments in a basket. When the balloon reached a very high altitude it burst, and the parachute brought the instruments safely to earth.

And even now they are far from being perfect, for important regions still lie outside the range of telegraphic reports. Since 1909 wireless weather messages have been received from some Atlantic steamers, but these reports do not yet properly cover all the ground of observation necessary in forecasting the movement of storms between the Arctic seas and the Atlantic Ocean. In 1910 one of the gales that carry depressions across the western region of the Atlantic was advancing on our islands, bearing a mighty storm on its wings. A cyclone of this sort often travels at the speed of twenty miles an hour. But in this case the deep depression remained stationary in mid-Atlantic for a week, while a high-pressure area surrounded the British Isles, with constant fair weather. Naturally the forecaster continued to expect the storm to arrive, and only a long chain of observing stations across the Atlantic could have enabled him to keep the motionless cyclone constantly in view, and leave it out of consideration until it actually began to move. Perhaps when all steamers are equipped with more powerful transmitting instruments than have yet been designed for marine use, the weather information from the Atlantic Ocean may become a most important factor in our weather forecasts.

In this case the peoples of Europe will benefit almost as much as we shall. For our Meteorological Office is the chief storm

forecaster for the Continent, by reason of the fact that the British Isles form the main gateway of the Atlantic disturbances. Speaking generally, our cyclonic storms come suddenly sweeping in from the western ocean, while our anti-cyclonic systems of clear, still weather gradually extend to us from the Continent. At the height of summer we often manage, with the help of an anti-cyclone wedge from France, to shunt most of the Atlantic tempests to the north of our islands. But in August of the present year a great anti-cyclone stood fixed in the sub-Arctic region, and another similar vast area of high, dense air stretched below our country to the south. So the disturbances of air that swept across the Atlantic found a straight and easy path over our islands, and we passed them on to middle Europe. Sometimes, when the way is clear, one of our sea-bred cyclones will travel as far as Siberia.

It will thus be seen that our bad weather conditions are critical for many mid-European countries. Our own critical points in the manufacture of storms are the West of Ireland and the southern English coast. In the West of Ireland high southerly currents of air often become transformed into gales, and in the Channel coast mild easterly breezes get intensified into high winds. When we are able clearly to discern and measure the conditions that bring about these swift and great changes of our atmosphere, the task of the forecaster in our Meteorological Office will be made easier.

At present two main lines of research are being pursued by our scientists with a view to obtaining more knowledge of the factors of the weather problem. On one hand, they are carrying out a careful and laborious scheme of studying the conditions of the upper atmosphere of the earth in relation to the surface currents of air that are felt in stormy and squally disturbances. This is being done partly by Mr. W. H. Dines at a meteorological station at Pyrton Hill, Oxfordshire. Kites and balloons, fitted with automatic recording instruments, are employed. Other upper air-stations, most of them under the direction of Mr. Dines, have been established in our country; and already a good deal of sound and useful knowledge concerning the temperature and direction of the chief movements of the upper

PLACING STORM SIGNALS ON THE ATLANTIC COAST OF THE WEATHER-MAP IN AN AMERICAN METEOROLOGICAL STATION

atmosphere has been obtained. And all this new field of study is helping to illuminate the weather problems of the lower air that immediately concern mankind.

In France and the United States some very valuable work has been done by means of kites and balloons. And recently some enterprising Germans went to East Africa with a large number of self-registering balloons, with a view to studying the origin and structure of the monsoons that fertilise India. In the very middle of the equatorial belt they discovered a new western wind flowing above the regular easterly currents of the equatorial region. But more important at present in the actual practice of weather forecasting is the method that has been worked out in India for foretelling the amount of the coming rainfall that will be produced by the wet monsoons. As is well known, these winds are the life-force of the Indian peoples. When they fail to shed rain in necessary quantities upon the parched and scorching lands, severe famines result. So the forecasting of the monsoon is a matter of vital importance.

A KITE-RAISED WEATHER RECORDER

This instrument records the wind-force, air-pressure, temperature, and humidity of the upper regions of the atmosphere

The forecasting is now achieved with an extraordinary amount of success, by calculating all the principal factors in the creation of the monsoon. The pressure of the air is studied at Mauritius and Zanzibar and elsewhere; and the atmosphere of India, towards the close of the hot season, is also weighed by the mercury column of various barometers. Then the snowfall in May of each year on the Himalayas is carefully estimated; and by combining all these creative factors, and bringing into the calculation the amount of rain that fell in India the previous year, the strength and the date of arrival of the great rain-winds are worked out.

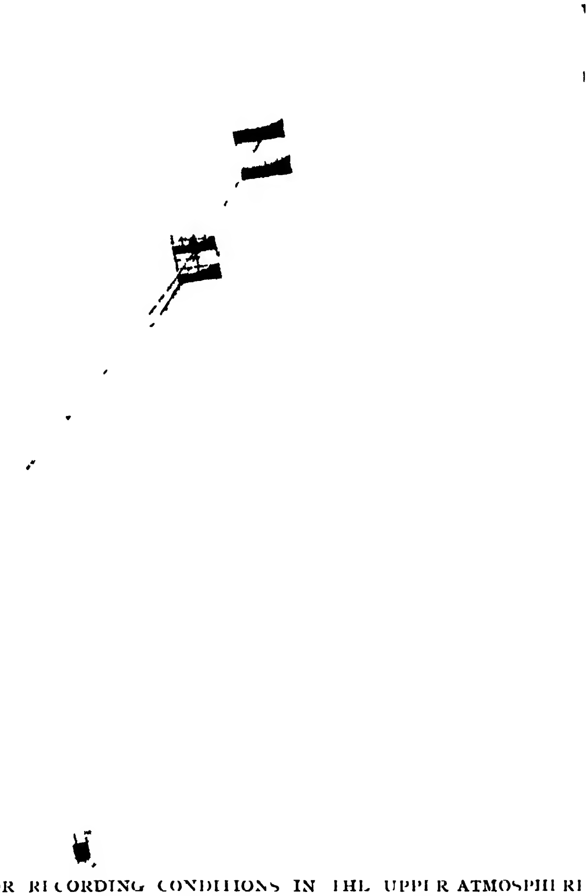
The exactness with which the monsoon can now be foretold by the British men of science working on the weather conditions of India is one of the most marvellous achievements of modern meteorology. It is the first large advance that man has made in the most intricate and momentous problem of human life—the problem of food production. It is more than possible that the success which our weather scientists have obtained in India will at last be repeated in the British Isles. At least, it would seem that if we could discover a critical point, or a series of critical points, where the conditions that greatly influence our weather could constantly be studied, we should be able to make fairly long and fairly exact forecasts of the western storms which are our greatest difficulty.

Only a few weeks ago the Meteorological Office published an extremely interesting work by Commander Hepworth, which has some bearing on the matter. It looks as though the Labrador current is as vital a factor in our weather conditions as the snows of the Himalayas are in regard to the Indian monsoon. Commander Hepworth deals with the effect of the Labrador current upon the surface temperature of the North Atlantic, and with the effect of the latter on the air pressure and temperature over the British Isles. He shows from records of the last eight years that abnormally low temperatures in the North Atlantic are directly due to the current of cold water from the coast of Labrador, and not to the ice that the current brings with it. The low temperature of the water lowers the temperature of the atmosphere over our distant country, by cooling the winds from seaward, by influencing the path of stormy depressions, and by diminishing cloudiness. When the north-eastern arm of the Atlantic is colder than usual, the centres of the cyclones sweep almost directly over the British Isles, and produce excessive cloudiness and rain. Thus it looks as though the key to our weather problem, and to a good many of the troubles of Europe forecasters, has at last been found.

If a well-trained observer could be

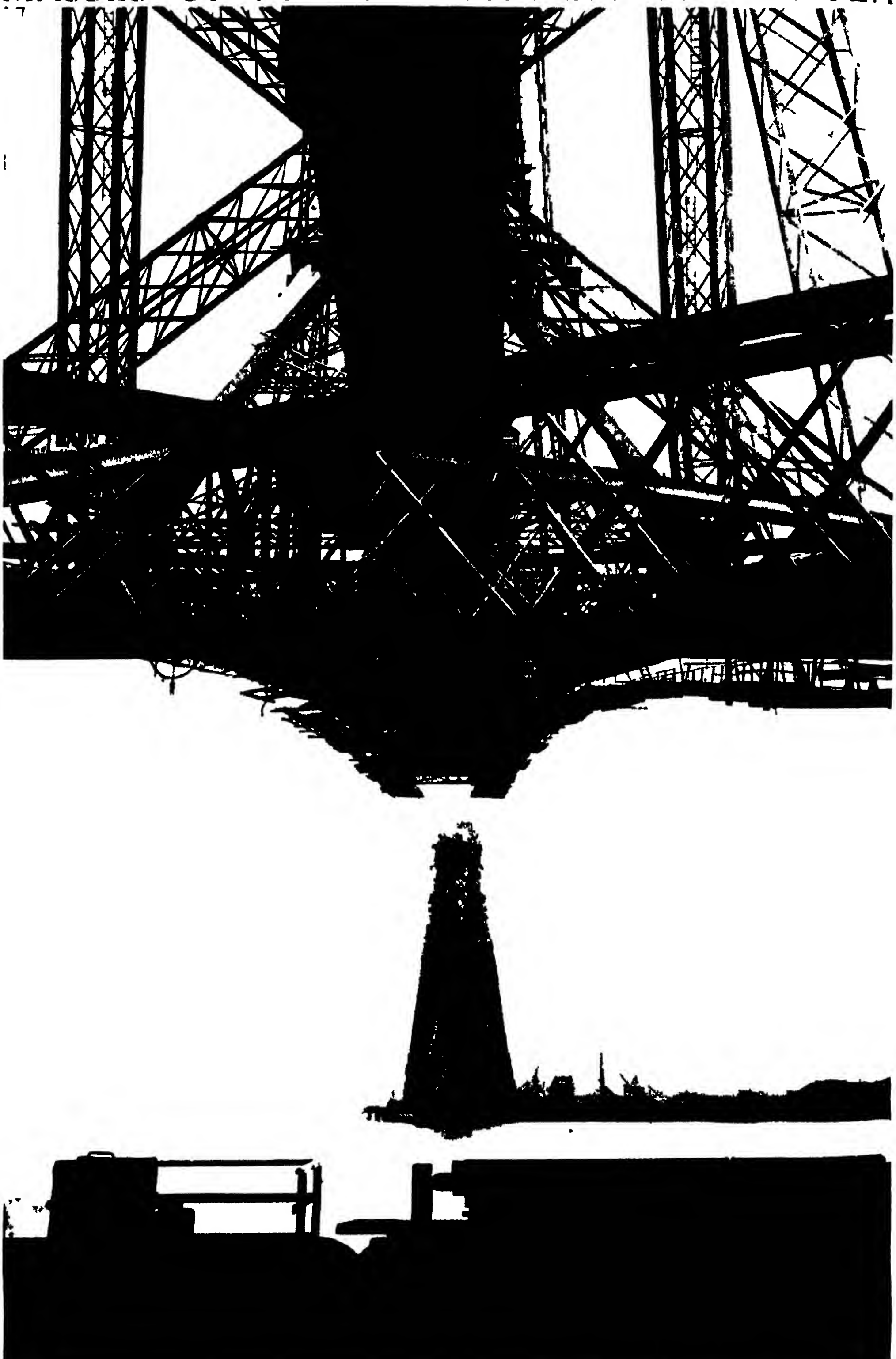
stationed off Labrador, and connected by wireless telegraphy with the Meteorological Office at South Kensington, our clerk of the weather might be able to make a longer and surer forecast than is now possible. He would still be faced with the difficulty of determining the speed of the cyclones that were travelling across the Atlantic towards us. But if, as we have already remarked, every big liner and cargo-boat plying across the ocean sent him, twice daily, wireless messages of the weather they encountered, he could extend his chart from the British Isles and Iceland to the Labrador, Canadian, and American coasts. The only unknown factor then remaining on his field of survey would be the conditions of the atmosphere in Greenland and the Arctic Seas.

Undoubtedly an element of instability and incalculability will for ever remain in weather forecasting. But though the science of charting observations is scarcely more than fifty years old, there is now a fair promise that man will obtain a very useful amount of foreknowledge of weather conditions. Already many farmers and men of business in the United States rely on their Weather Bureau for information by which they guide their actions. For they have found the forecaster is so often correct that large sums of money are saved every year by trusting to his report. And it is hoped that, when telephonic communications are extended and cheapened, all the agricultural activities of our own country will be improved by a general daily reliance on the work of our Meteorological Office, though it has to contend with a series of problems more obscure than those of a continental region of survey. But, as in the case of India, the difficulties of our situation may at last inspire our weather scientists with a new and larger method of dealing with the matter. Besides watching for and tracing the movements of air across the oceans, they may at last be able to find at some scattered points, nearly half way across the world, trustworthy indications of the disturbances of climate in our changeable islands.



TWO KITES LIFTING A METEOROGRAPH FOR RECORDING CONDITIONS IN THE UPPER ATMOSPHERE

MASSES OF STEEL OVERHANGING THE SEA



THE FORTH BRIDGE UNDER CONSTRUCTION, AS SEEN FROM THE BASE OF A CANTILEVER

SPANNING THE WATERS

The Story of the Modern Development of the Indispensable Science of Bridge-Building

SOME OF THE WORLD'S GREAT BRIDGES

The archetypal forms of bridges loom out from the mists of a high antiquity. Whenever a savage stretched a rope of fibre or of strips of hide across a river or chasm, in that lay the embodiment of the principle of the latest suspension bridge. If he threw a tree-trunk over, he anticipated the girder bridge. When he overhung logs from opposite sides to meet in the centre, he anticipated the true cantilever bridge. If he inclined two logs or stones towards each other, and covered and connected them at the top with a flat stone, he came very nearly devising the cantilever and girder bridge in one direction, or the arch in the other. Travellers have given accounts of many such bridges of greater or less antiquity. The Chinese, for example, have ever been notable bridge-builders.

The real history of bridge-building, however, as we understand it, came in with the immense aqueducts of Roman workmanship, the remains of some of which survive almost intact to the present time. One of the most ancient arches is that of the Cloaca Maxima, the great sewer of Roman construction, about 615 B.C., with a span of 14 ft. Aqueducts remain both at Rome and in various parts of her ancient provinces. Many of these structures date approximately from the Christian era, and some remain in service today. Several old stone Roman bridges survive in the North and West of England, arched bridges of small span. Many Roman bridges must have remained in service during the period of the Saxon occupation. The earliest Saxon rates on land included one for "brig" tax.

The art of building bridges dropped into abeyance with the fall of the Roman Empire, until it was revived by the monks of the Middle Ages. The frequent occurrence of the term "ford" on the great roads testifies incidentally to the absence of bridges. Bridge building and repairing in the Middle Ages were accounted among the works of piety.

The first arched bridge built of stone in England in post-Roman times appears to have been the triangular one near Croyland Abbey. It is believed to have been built about 860 A.D. The three arches meet in the centre, and carry three roadways over three waterways that now are dry. Perhaps, as some have surmised, the religious sentiment of the builders sought to materialise in it their faith in the Trinity.

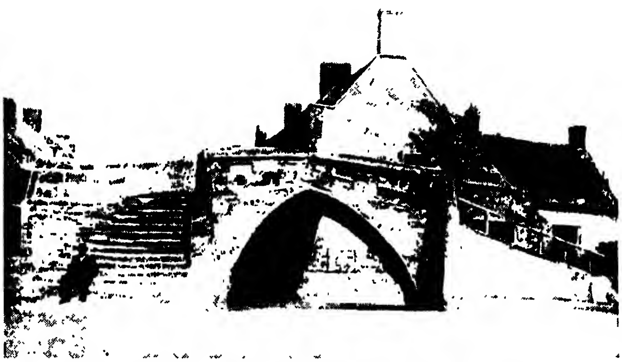
An early road bridge built of stone in England was one over the Lea, at Stratford, at which ford many lives had been lost. When Queen Matilda, consort of Henry I., narrowly escaped drowning there, Bow Bridge was ordered to be built. With the fall of the monasteries the art began to decay, and the spoliation under Henry VIII. completed the débâcle.

Until the eighteenth century the Thames was spanned only by London Bridge. In the absence of bridges the ferries or the fords were the only means by which rivers could be crossed, and these were under the charge of religious houses. There was a ford at Westminster ages before the Abbey was founded. The story is familiar of John Overy, the penurious City ferryman, his tragic death, the foundation of the church with his gains, and the college of priests therewith associated who built the first wooden London Bridge, 993–1016. Danes and Saxons fought a fight which entailed the destruction of the bridge. Repaired, it was swept away by a flood, and a new one was erected in 1097, which was burnt down forty years afterwards. Patched up, it remained until the stone bridge—*the* old London Bridge—was begun in 1176 by Peter, the chaplain of St. Mary's Colechurch, in the Poultry. This church had a chapel dedicated

to St. Thomas of Canterbury who had been baptised in it.

Old London Bridge shared in the storm and stress, the pomp and tragedy, of the life of the metropolis for six hundred and fifty years, when Normans and Plantagenets and Tudors were making history, and through the times of the Stuarts and Hanoverians. Peter, like his great successor Rennie, did not live to see his work completed. The bridge was 923 ft. long by 40 ft. wide, and stood 60 ft. above high water. It consisted of nineteen pointed arches. The piers were very thick and the arches very small, and many lives were lost by the capsizing of boats. In the early part of the eighteenth century water-wheels were still in existence under two of the arches of the bridge, one wheel under the first arch next the City, and three under the third arch. They were used for pumping water from the river. They ran with the tide, so that the direction of rotation changed with the ebb and flow. For many years the bridge cost an average of £3500 for repairs, but it endured until 1833. In 1824, Rennie's bridge was begun, and opened in 1831. It cost about £1,500,000.

The art of bridge-building was revived by Telford, Rennie, and Brunel in the eighteenth and early nineteenth centuries. How very low the art had sunk may be inferred from the fact that the building of old Westminster Bridge, the second stone bridge over the Thames, 1738–50, was committed to one Thomas Labelye, a Swiss engineer. He used caissons for the foundations, within which masonry was built up, encircled with sheet piling to prevent scour. This bridge had thirteen semi-circular arches. But the scour of the stream proved too great for the structure, and the present iron bridge of seven arches took the place of the old one.

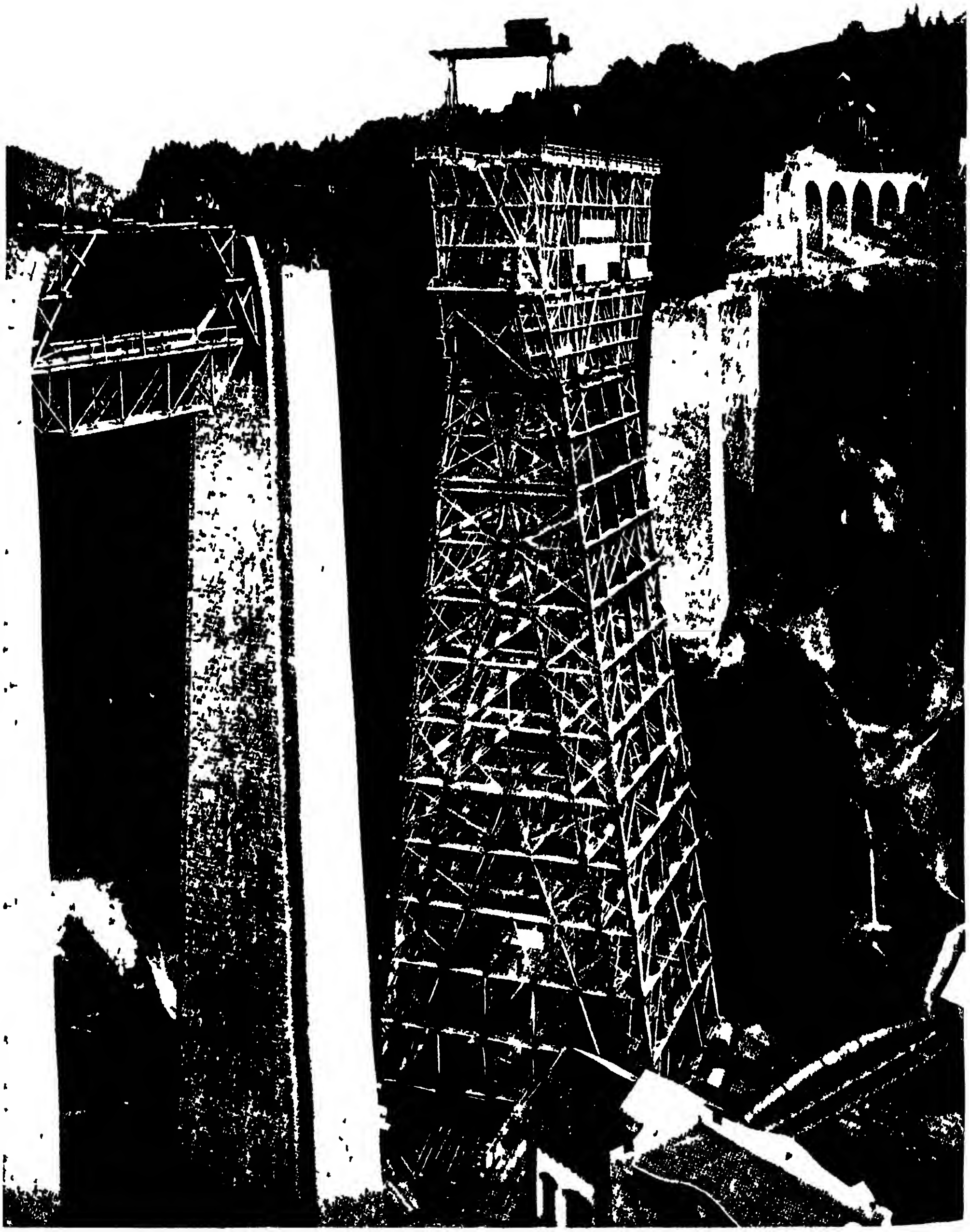


THE TRIPLE-ARCHED BRIDGE AT CROWLAND

Bridges include a number of distinct types, roughly classified as built in masonry, in steel and concrete, formerly but rarely now in timber, and in cast and wrought iron. Arched bridges are made in all materials. Girder bridges formerly built in wrought iron, are now built in steel. They are either plated girders in wrought iron and steel, or lattice-braced girders in each material. Deck bridges are those in which the floor occupies the top members. Bridges are continuous when the girders cross more than one span in one length of girder. Bowstring girders have one boom curved. Cantilever bridges overhang from their piers or supports, of which three variations are recognised in bridge-building. Suspension bridges form a type by themselves. Roller bridges, bascule or hinged bridges, lifting bridges, swing bridges, form a large group with moving spans, in each of which considerable variations occur. Transporter bridges are another group.

THE CHAPEL ON THE BRIDGE, ST. IVES, HUNTINGDON

Arched bridges are built in masonry and in all materials that are used by the engineer. Such a bridge may be of any length, but its spans cannot be so long as those of some other types. The great arched bridges and viaducts of the Romans have been already mentioned, and the subsequent decadence of the art of their construction. The reason why these structures have endured so long is that the foundations



THE MOUNTAIN OF SCAFFOLDING THREE HUNDRED FEET IN HEIGHT USED IN CONSTRUCTING A BRIDGE ON THE BODENSEE TOGGENBURG RAILWAY ACROSS THE SITTER RIVER SWITZERLAND

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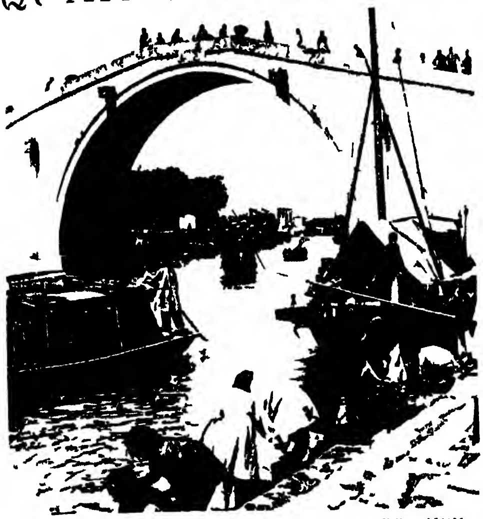
QUAINT BRIDGES IN MANY COUNTRIES



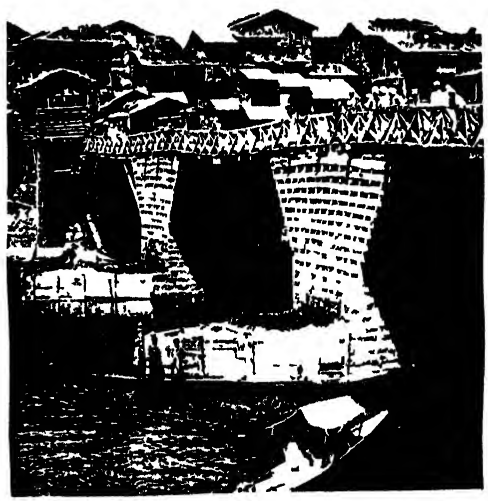
THE ARCHED WOO-MAN BRIDGE AT SOO-CHOW

MEDIEVAL HOUSES ON A BRIDGE AT NUREMBERG

A RAW-HIDE TOLL BRIDGE IN INDIA

A WOOD AND STONE BRIDGE AT IWAKUNI, JAPAN

THE FOOT-BRIDGE NEAR GIANT'S CAUSEWAY



A LOG BRIDGE IN SRINAGAR, CASHMERE

were sound. The Romans built on clusters of piles, surrounded with concrete. The scour of streams in flood which undermined and destroyed hundreds of bridges built subsequently in the Middle Ages and in the eighteenth century has not injured the more ancient structures.

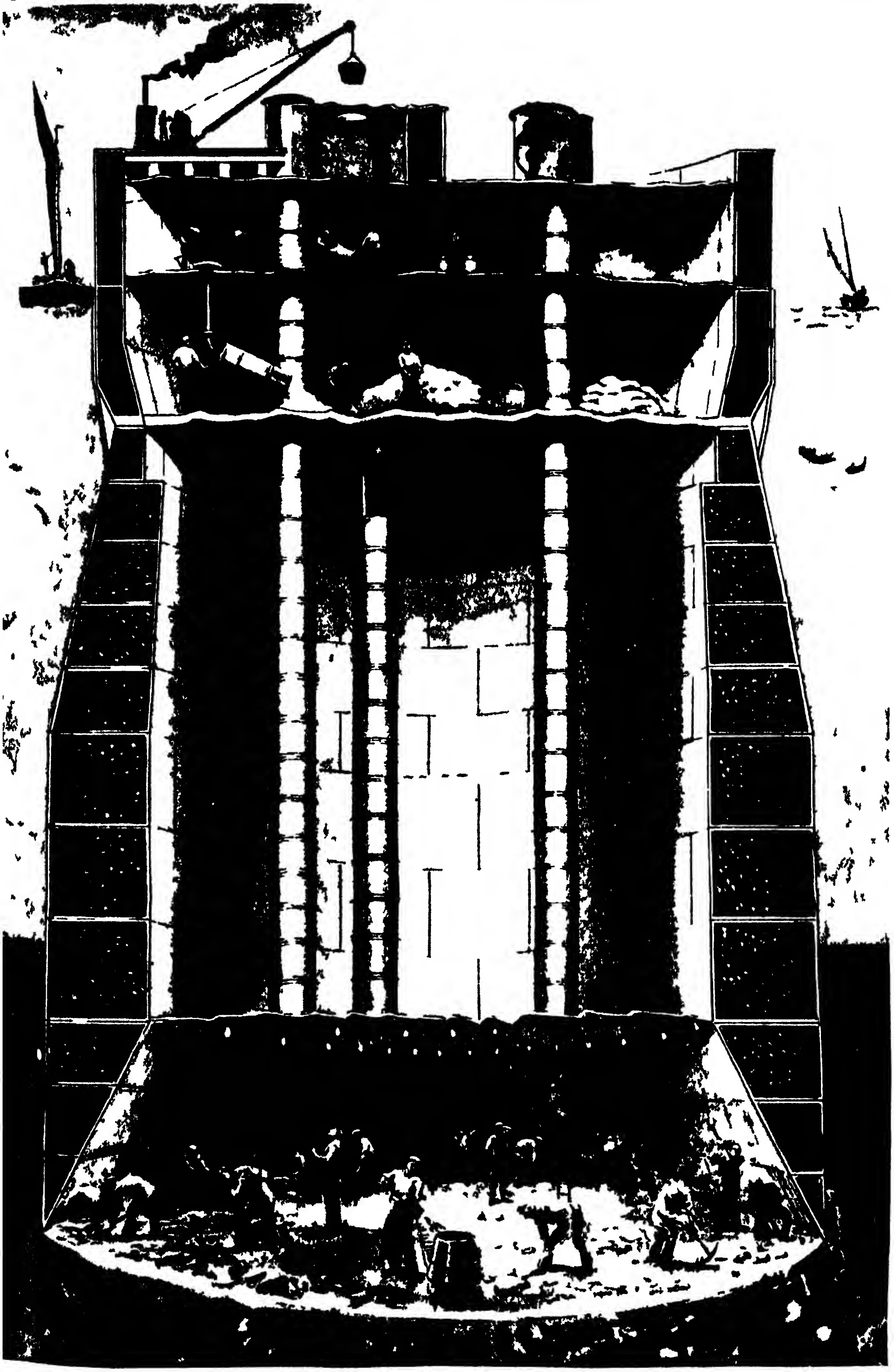
Probably the largest masonry span in the world is one which was completed in 1901 across the valley of the Petrusse, at Luxembourg. It measures 277 ft. 6 in. in the clear. The arch is elliptical, and contains 26,000 cubic yards of masonry; 13,420 cubic feet of timber was used in the centring.

The first arched bridge of cast iron ever built and completed is still in existence at Ironbridge over the Severn. It has a span of 100 ft., with a rise of 45 ft. It weighs 378 tons, and stands as when constructed in 1779–80, except that it is now distorted by the pressure of the earth behind the abutments. The crown has been thrust upwards by the pressure, giving it a peaked aspect suggestive slightly of a Gothic arch. Three miles higher up the Severn, at Buildwas, the second cast-iron bridge was built by the firm of the Coalbrookdale Works, who had built the other. It occupied a site twenty or thirty yards higher than that of a Norman bridge erected by the Cistercian Abbey in the twelfth century. This was washed away at the close of the seventeenth century, and replaced by one which shared the same fate in 1795. The cast-iron bridge was built in the following year. This was demolished so recently as 1906 to give place to a bowstring lattice girder bridge; and the reason for the replacement was that no allowance had been made for expansion, and the bridge had become distorted to a dangerous extent. The ironwork of the old bridge was bought by the firm which had built it 110 years previously. The Wearmouth Bridge was being built at the same time, 1796, with a span of 236 ft. and a rise of 34 ft. It cost £27,000. From that period until the introduction of wrought iron, cast iron divided favour about equally with stone and timber for arched bridges.


THE ROMANS WHO BUILT FOR ALL TIME—PONTE PIETRO, VERONA, AND AN AQUEDUCT

In bridges, things are not always what they seem. There is a group which most people would term arched structures. In appearance they are so, but in strictness they are pivoted and balanced curved girders. The Mirabeau Bridge, which crosses the Seine at Paris, is an example of this character. It stands for a type much favoured by some engineers,—that of an elastic instead of a rigid structure, and it is one peculiar to work done in iron and steel being impossible in masonry. In a masonry

A HIVE OF INDUSTRY BENEATH THE SEA



iagram of a caisson used in the construction of the Forth Bridge shows how workers in ressed air dug out the bed of the estuary until they reached the solid rock on which they built ry. To this were bolted the massive pillars of hollow steel for the attachment of the cantilevers

arch the keystone in the crown completes a rigid structure. In the elastic type the centre of the span where the keystone should be is flexible, being pivoted on a pin, and the arch is also pivoted at its springings on the piers. The half-spans at the rear are connected freely to the abutments with links. So that at three points each half of the Mirabeau Bridge is free to move when its length is affected by alterations in temperature.

A development which may have the effect of rehabilitating the arched bridge is that of the use of ferro-concrete. The material is of a composite character, because concrete is not reliable in tension, though admirable in compression. Ferro-concrete, therefore, is built up as a solid mass of concrete around a skeleton of steel suitably disposed and arranged to resist the particular stresses which are imposed upon it. If the ingredients of the concrete are properly proportioned and suitably mixed, it is very reliable. But the "if" is ever present. Accidents have happened, and engineers are therefore as yet chary of using concrete for bridges of large dimensions for heavy traffic. The same remark applies to piles made of reinforced concrete. The old methods of timber-piling and of depositing concrete within caissons or coffer-dams is still preferred. But several large span bridges have been built in reinforced concrete. The largest is one in Auckland, New Zealand, which has a span of 320 ft. and a height of 147 ft. The roadway is 24 ft. wide.

The oldest girder bridge is one on Dartmoor, perhaps contemporary with Stonehenge. Three piers, originally, of rough granite blocks, supported granite slabs about 15 ft. long and 6 ft. wide, though one of the piers has fallen. In the early days of railway work many girder bridges were constructed of timber in all countries, but especially so in America. The timbers were framed together to form trusses of various shapes. But first cast iron and then wrought iron, and frequently combinations of the two, displaced most of these.

Whenever a new material is introduced, old models are retained. When cast iron came in, the arched form of stone bridge was built in cast iron. So when wrought iron followed, the solid plated girders reproduced the shape of the cast-iron girders previously used in the construction of viaducts and small bridges. But with increase in dimensions these girders became too unwieldy, and imposed great loads on the abutments and piers.

The Britannia and the Conway tubular bridges are examples of this class of heavy plated work. Besides these, hundreds of small girder bridges with solid plated sides still exist all over the country for railways and for road service. That, however, is not only a very wasteful disposition of metal,

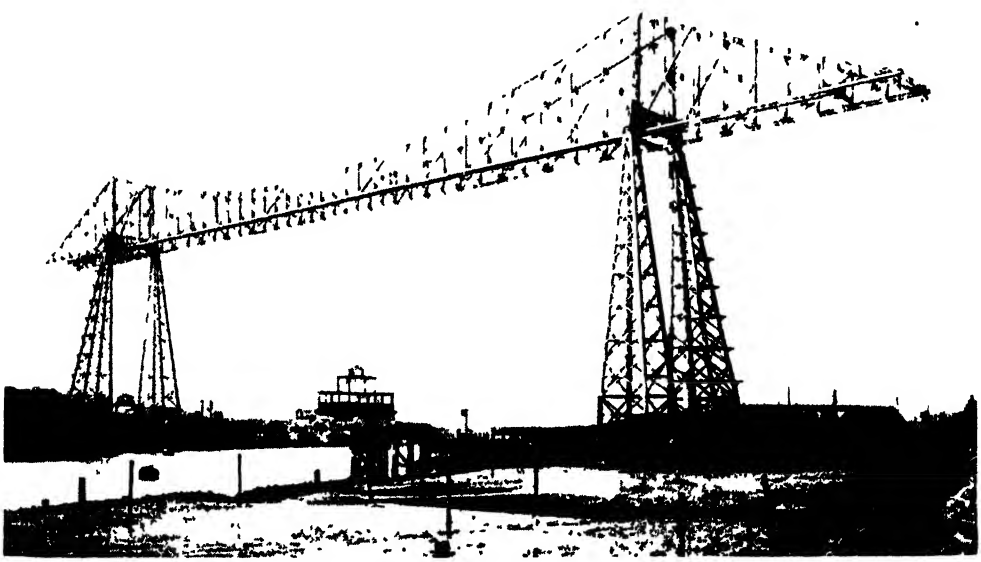
THE CLIFTON SUSPENSION BRIDGE THAT HANGS 287 FEET ABOVE THE AVON

but it is one that is liable to distortion. A girder can be built quite as strongly with less than half the quantity of metal if that is disposed in the form of bars arranged along the lines of stress. No one now builds long bridges with solid plates, though many of the earlier ones were so constructed. All bridges over, say, about 200 feet in length; and some which are much shorter, are built with lattice-work. The lattice-work is lighter, saving thousands of tons of weight in a big bridge. But here very careful calculations become necessary, when the strength of every bar has to be calculated singly.

The Britannia tubular bridge stands for the old style. It consists of two independent wrought-iron solid plated beams of rectangular section, each 1511 ft. long, and weighing 4680 tons each. They are 23 ft. deep at the ends, 30 ft. deep at the centre, and 15 ft. wide. The length is divided into two spans of 460 ft. and two of 230 ft., resting on piers 100 ft. above high water. It was opened in 1850, and cost £601,865.

The rapid growth of the vast American railway system developed styles in bridge-building which are almost wholly peculiar to that country. Timber was so plentiful that the early bridges were all built of that material, disposed in various forms of trusses, each type being familiar under distinguishing names. Such bridges are, however, short-lived; and as the vast extent of country became peopled and settled, most of these bridges have been replaced by those of iron and steel, and the tracks have also been relaid. But the iron bridges are built after designs similar to the old timber ones. Instead of flat pieces of timber, flat bars of iron, and afterwards of steel, are used. And instead of uniting these with rivets, as is universally done in England, they are nearly all connected loosely with round pins, and thus the American types of bridge have been evolved and perpetuated from the early days of timber construction.

The rivers of India are subject to great and sudden floods. Many are also very wide. The subsoil varies so greatly that nearly all conditions possible which give the engineer cause for anxiety, save that of floating ice, exist in the vast peninsula. For the most part the bridges are the creation of the railways, and they are what are termed continuous girder bridges—that is, they consist of a succession of lattice-braced girders, all alike supported on piers at intervals.

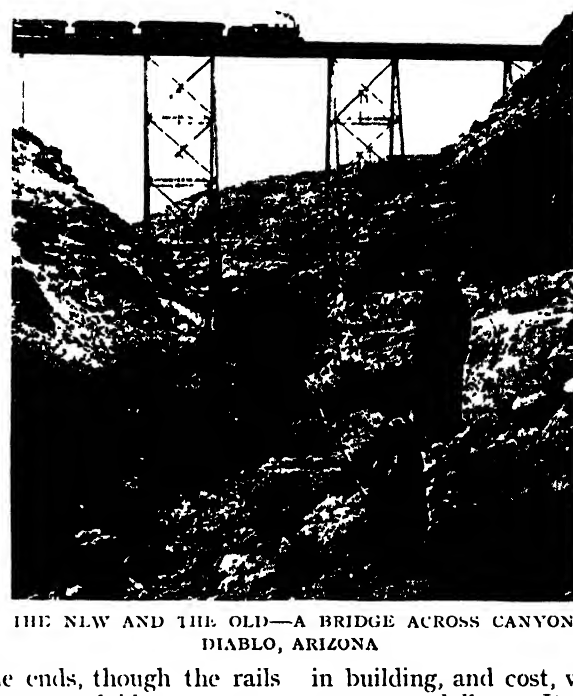


A TRANSPORTER BRIDGE AT MIDDLESBROUGH WITH THE CARRIAGE IN TRANSIT

In 1901 an immense bridge was completed over the Godavari River, at Rajahmundry, to carry the East Coast Railway of India. It consists of fifty spans of 150 ft. each, and one of 40 ft., and its total length is 9096 ft., or nearly 1¾ miles. The bridge is of the deck type with trusses suspended. Although large portions of the channel are dry in the dry season, the bridge was built to span the stream when in flood. The flood discharge is very great, being 1,500,000 cubic feet a

second, and it moves at a velocity of from 4 ft. to 11 ft. a second over the whole width of the channel. The state of the channel in the dry season was favourable to the building of the piers and the sinking of their foundations, which were taken down from 48 ft. to 100 ft. below low water. Only six of the piers were in deep water, for which caisson-sinking was adopted, the men working in compressed air under a pressure of 20 lb. per square inch, and in a temperature of 96 deg. Fahr.

For the rest of the piers, well-sinking was adopted, the soil being dredged within circular curbs, which were afterwards filled with concrete. The masonry above had to be transported distances of 64 to 115 miles. The girders were floated out on pontoons into position, and then lifted into place by means of hydraulic jacks and chains in a gallows-framing that was erected on the piers. The bridge was begun in November, 1897, and completed in August, 1900. An interesting fact is that the curvature of the earth was easily detected by a theodolite, the bridge being 6 in. higher, due to this curve, in the middle than at the ends, though the rails were levelled as they were laid.



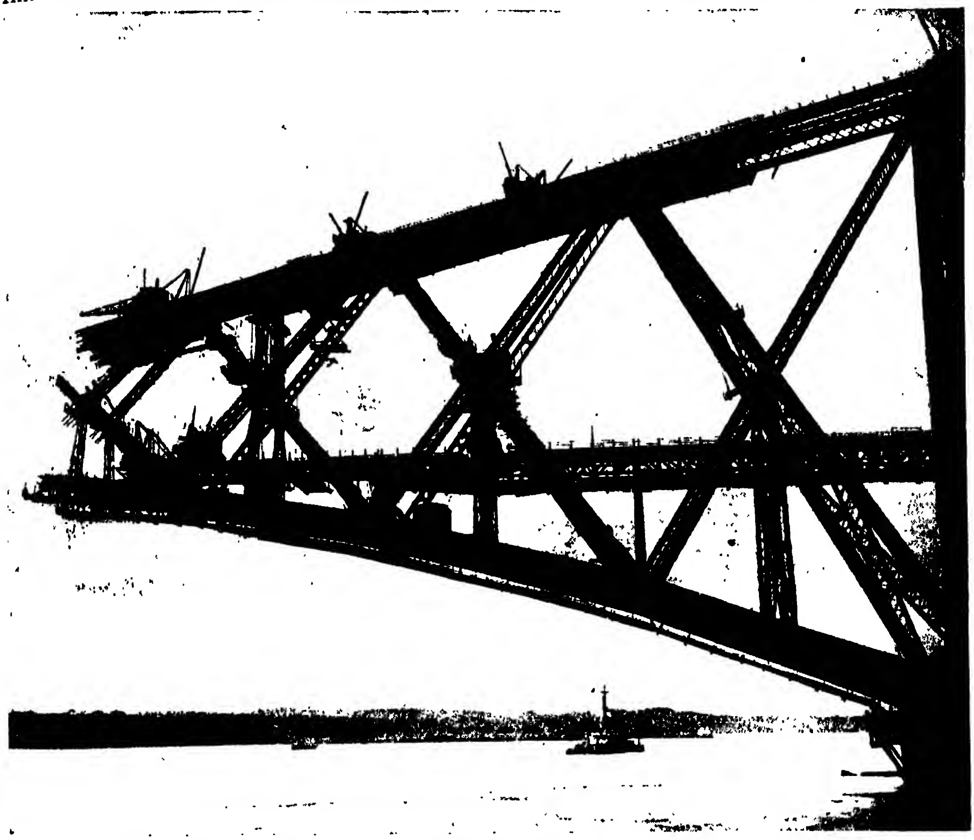
THE NEW AND THE OLD—A BRIDGE ACROSS CANYON DIABLO, ARIZONA

Archetypal cantilever bridges exist in wild regions. Timbers are built out from banks, being either strictly cantilevers, or, in some examples, of corbel design, and either being disposed horizontally or sloping upwards until they approach sufficiently near to be united by a single log or series of logs or timbers. The cantilever type came into much prominence in consequence of the adoption of that design for the Forth Bridge. That was the first large structure of its kind, but since then many others have been built, notably that of Sukkur, in India, and the Blackwells Island Bridge, in New York. America, more than any other country in the world, is the land of many bridges. They are unavoidable on her vast transcontinental railway systems. But the vehicular and pedestrian traffic of the great cities has also called into existence numbers of bridges of large dimensions. Among these those of New York stand prominent. The city and the suburbs are connected by the Brooklyn Bridge, the Williamsburg Bridge (both of suspension type), the Blackwells Island cantilever Bridge (opened in 1909), and by the Manhattan suspension Bridge, opened in 1909. These are in addition to tunnels and ferries.

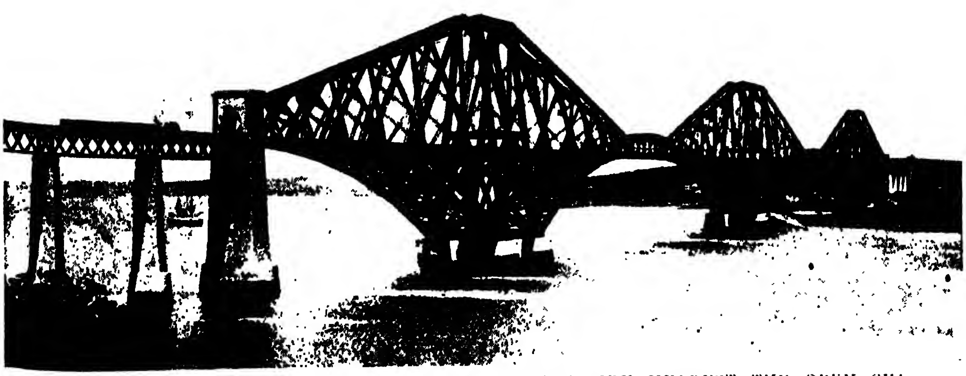
The Blackwells Island or Queensborough Bridge is situated three miles above the Brooklyn Bridge. It crosses the East River, where it divides into two deep tidal channels on each side of the island. Two main piers are erected on the island, one on each side; two more on the opposite shores, with another pier stretching further inshore. The spans over the channels are 1182 ft. and 984 ft. long respectively. The total length is 7556 ft. The bridge occupied eight years in building, and cost, with the land, about 20,000,000 dollars. It absorbed 70,000 tons of steel and 99,000 cubic yards of masonry of all kinds—quantities larger than those in the Forth Bridge. The rigid cantilever arms of the west span measure nearly 600 ft. long, and weigh over 8000 tons each. These were built out 135 ft. above the surface of the water. The arms which were built out from the island piers form a portion of the span built on the island, 630 ft. long. There is thus a continuous superstructure, 1713 ft. long, from centre to centre of the river channels, weighing 25,000 tons.

THE FORTH BRIDGE COMING INTO BEING

THE THREE PAIRS OF CANTILEVERS BEING BUILT OUT FROM THEIR ROCK-BASED CENTRES



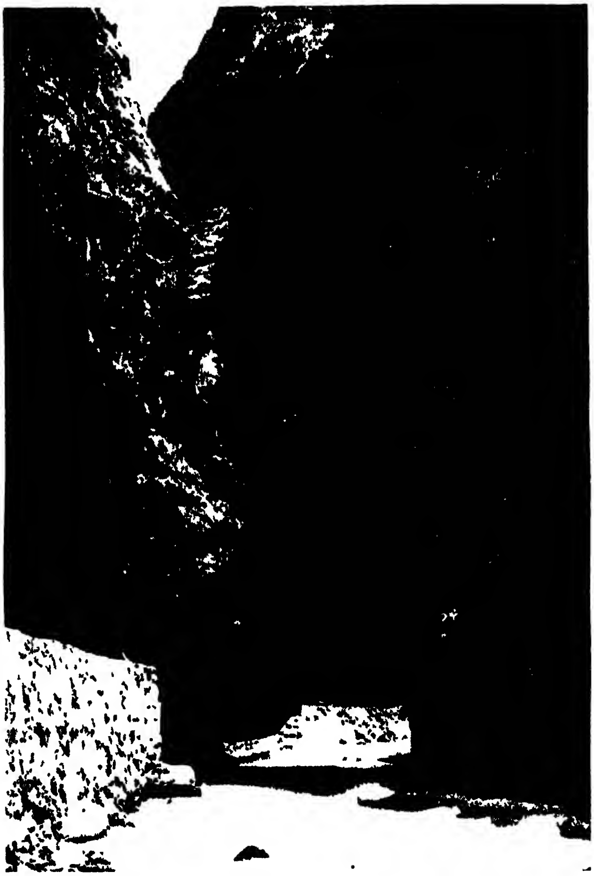
A NEAR VIEW OF ONE OF THE CANTILEVERS IN COURSE OF CONSTRUCTION



THE COMPLETED BRIDGE, AS VIEWED FROM THE SIDE NEAREST THE OPEN SEA

The difficulties of this work were almost incredible. In the summer the mercury often reached 100 deg. Fahr: in the winter it dropped nearly to zero, and fierce gales and snowstorms swept the river. Pieces of steel 100 ft. long and weighing 60 tons were handled at heights of from 100 ft. to 300 ft. above the crowded traffic on land and river but without interfering with or injuring public property or life. The island span was built on false work, or staging, of steel, weighing about 1700 tons, and entailing as much labour as that of building many railway bridges. This was built by means of travelling cranes, and on it were erected derricks of 65 tons power for dealing with the bridge itself. In addition, there were two travelling cranes 124 ft. high, which weighed about 625 tons each. All the bridgework was brought ready prepared from shops 100 miles away, by rail and river. Some of the pieces weighed 78 tons. Besides the rivets driven in the shops, 752,000 rivets were put in on the site. Twelve gangs of men, with four men in each gang, could drive 1000 rivets daily by means of hammers held in the hand, actuated by compressed air and striking about 1800 blows a minute.

The palmy days of suspension bridges occupied the period when wrought iron was superseding cast, and its best example in England is Brunel's bridge at Clifton, of 702 ft. span, 287 ft. above low water, the suspension chains of which were removed from the old Hungerford Bridge, erected by Brunel, 1841–1845, on the site now occupied by the Charing Cross railway bridge. The suspension chains are flat bars such as were rolled more easily in wrought iron than solid plates. American suspension bridges are far larger, and they are still built, the Manhattan Bridge being among the latest.



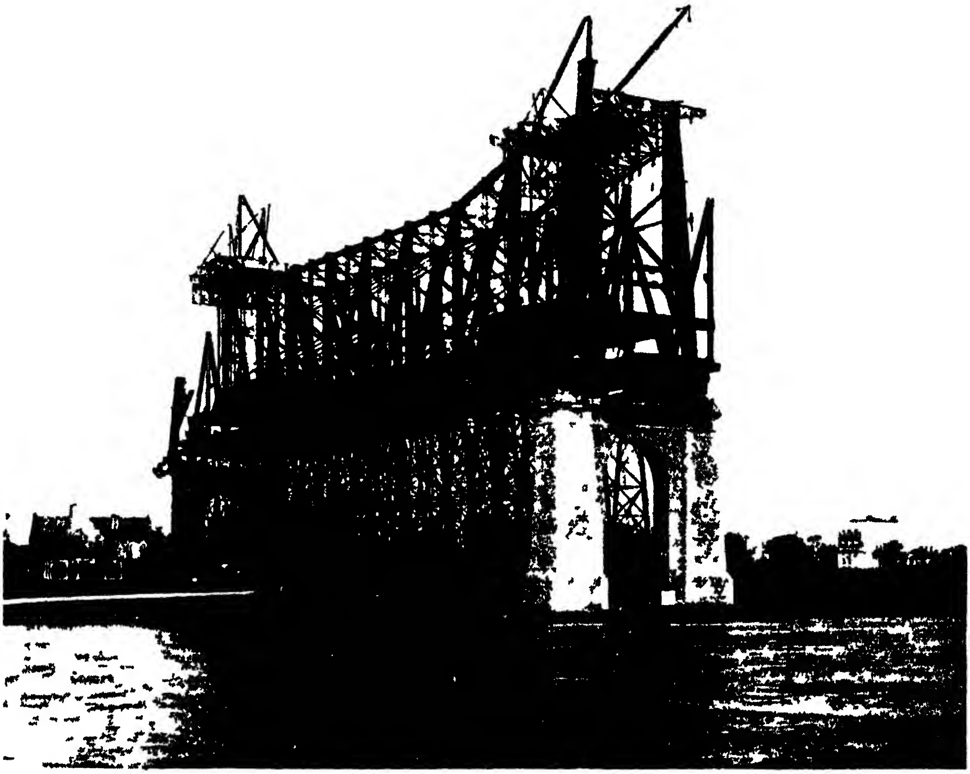
BRIDGE-ENGINEERING UNDER DIFFICULTIES

The hanging bridge built by the Denver and Rio Grande railroads in the Royal Gorge of the Grand Canyon of the Arkansas, in Colorado. The canyon is but 30 ft. wide at this point, too narrow to give space for the river and for the bridge in addition with the necessary ground supports

We might discern fashion in bridges. At present the steel lattice-girder bridge is dominant. But trouble is in store for the future, for corrosion proceeds insidiously in all parts which are not repainted frequently. For many years the suspension bridges were in vogue until the advent of the railways brought them into disfavour because of the elasticity of the supporting chains or wire ropes and bars and of the floor. Wire ropes for suspension bridges instead of bars were first used by Roebling at Niagara in 1851 on a span of 820 ft. His son finished the Brooklyn Bridge in 1883 with a span of 1350 ft. Iron wire was used for these cables. Each of the four suspension cables for the Niagara Bridge contained 3640 wires. In 1877 the cables were overhauled and found practically free from defects and they remain in service today. On the Brooklyn Bridge the cables are $15\frac{3}{4}$ in. diameter composed of 5296 wires.

The Manhattan Bridge is the latest connecting link between New York and Brooklyn, being the fourth for that service and, like the Brooklyn and the Williamsburg bridges, is of suspension design. In some respects it is more remarkable than either. The total length, including approaches, is 9330 ft., the centre span

TEMPORARY WORK IN BRIDGE-BUILDING

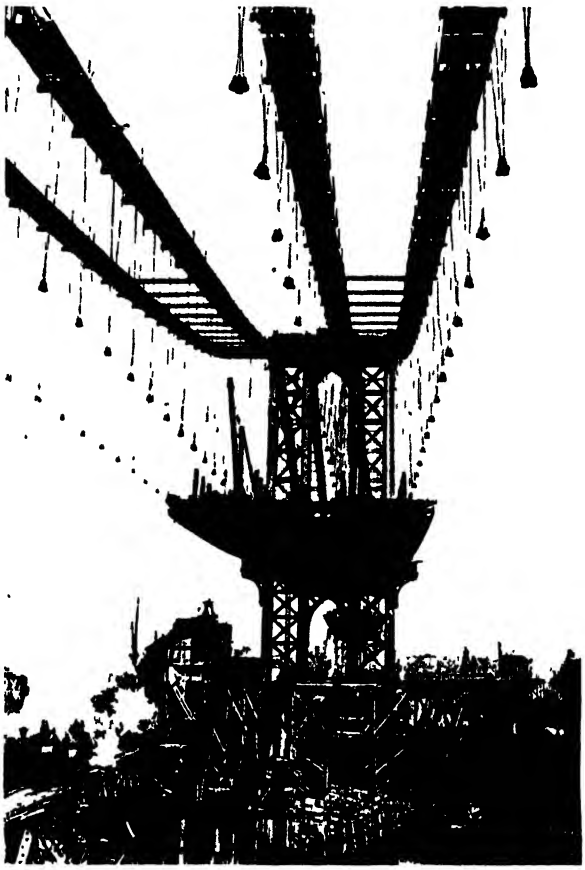


FALSE STEEL WORK USED IN BUILDING A SPAN OF THE BLACKWELLS ISLAND BRIDGE, NEW YORK

THE SAME SPAN WITH THE TEMPORARY STRUCTURE REMOVED AND CANTILEVER ARMS COMPLETED

measures 1470 ft., the two shore spans each 725 ft. The weight is supported by four enormous steel cables, each measuring 20¾ in. diameter, each one being built up of 9472 separate wires. The bridge is of double-deck type. The lower deck carries a roadway 35 ft. wide, and two sidewalks of 10½ ft. width for pedestrians. The upper deck carries four tramway lines and two railway lines for the city elevated railways. The width of the bridge is 120 ft., and the clear height at the centre is 149 ft. The foundations of the towers which support the cables are built in the river within great timber caissons sunk to a depth of 92 ft. below high water.

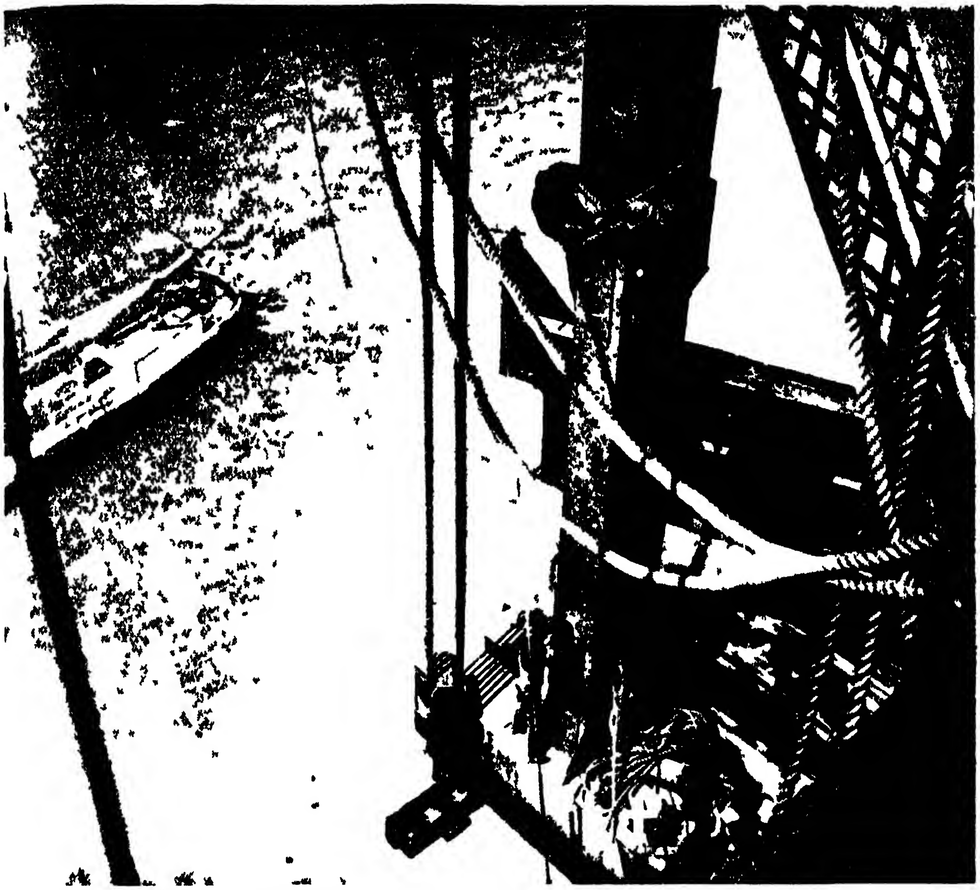
The difficulty of building a bridge is primarily that of the length of span, and secondarily the nature of the chasm which it has to cross. With increase in length all the labour and cost of erection is increased, no matter what method is adopted. Yet the largest span possible is always desirable, in order both to leave the largest clear waterway and to lessen the risk of the scour of tides and floods, which are liable to undermine foundations. So that to the engineer the span and not the total length of a bridge appeals to the imagination. The Tay Bridge, apart from its tragic memories, is not counted among the world's notable bridges, although it is one of the longest, because its greatest spans measure only 245 ft. in length. From this point of view the Forth Bridge bulks larger than any other, since its two main spans measure 1700 ft. from pier to pier. The next largest cantilever bridge is that of Sukkur, in India, with spans of 820 ft. Brooklyn Suspension Bridge has a span of 1600 ft.; but the work of erecting a suspension bridge is far easier than that of building a cantilever bridge out from its pier. Sir Benjamin Baker once said that "whenever a single telegraph wire could be got across a river or gorge, there could a stiff and strong suspension bridge be erected." That is how the Zambesi Bridge was built. The heaviest girders can be erected by the aid of cables, which are composed of a number of wires. Most suspension bridges have been built in this way.



THE ROADWAY OF THE MANHATTAN BRIDGE IN COURSE OF ERECTION

Six methods of erecting bridges are adopted — staging, which includes centring used in arched masonry and concrete work, and staging built up in a stream and carried up to the height of the under side of girder bridges, upon which, as on terra firma, the bridge spans are built; the floating of the finished bridge in sections, or in its entirety from a location on the shore adjacent into the stream on pontoons; the pushing out or protrusion of the finished bridge from the bank to its place over the stream; the building out gradually from the abutments or the piers; the erection by means of chains or cables thrown across the chasm.

Centring is the only method practicable when an arched bridge of masonry is built. It is essential, because the stones which compose the arch possess no stability whatever until the crown is completed by the insertion of the keystone. The centring must remain in place until the mortar has set. The early cast-iron arched bridges

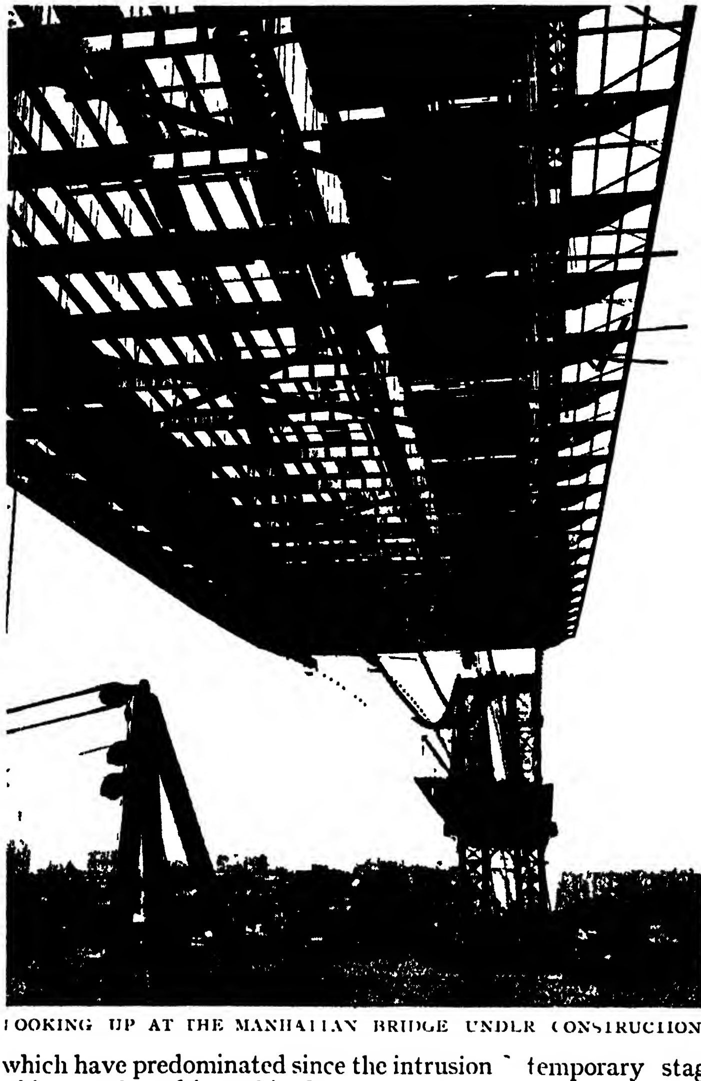


MEN AT WORK DURING THE CONSTRUCTION OF THE BLACKWELL'S ISLAND BRIDGE ACROSS THE EAST RIVER

MEN AT WORK ON A TEMPORARY FOOTPATH DURING THE BUILDING OF THE MANHATTAN BRIDGE

were built after the model of the masonry prototype. Short segments were laid together by their ends, and bolted up. Centring was necessary also for these.

Erection upon staging fell into disuse slowly. No other method was employed until 1850. It is still often adopted not only when arched bridges are built of masonry or concrete, but also for straight girder bridges which have predominated since the intrusion of iron and steel into this class of structure.


LOOKING UP AT THE MANHATTAN BRIDGE UNDER CONSTRUCTION

Stagings are usually, though not always, built of timber. As they generally involve some piling to support them, and as the quantity of timber required is large, its cost bears a heavy proportion to that of the permanent structure. But when a bridge is composed of several spans the cost is lessened proportionally, because the same staging can often be used for successive spans. The great objection to staging in many cases is the risk of its being washed away by sudden floods or by driftwood or ice, and also by vessels colliding with it. Again, when the depth below the bridge is great, the work of erecting staging becomes increasingly risky and difficult.

As a set-off against all these drawbacks, there is the immense benefit to be derived from the possession of a solid level platform on which the bridge can be built up piece by piece. Further, the method is suitable for the erection of all kinds of bridges, whether arched, straight, bowstring, suspension, or whether they are built in short lengths or as a continuous girder. It is further a safe method, because the bridge is not subjected to those unnatural strains which come upon it when it is pushed over bodily into place. It also frequently saves valuable time, since the erection of a staging can be proceeding while the bridge-work is being prepared. This method therefore, has frequently been adopted when great dispatch has been essential, as in the replacement or renewal of damaged or weak bridges. For these reasons, stagings bulk very largely in bridge construction when the conditions exist that are favourable to their erection.

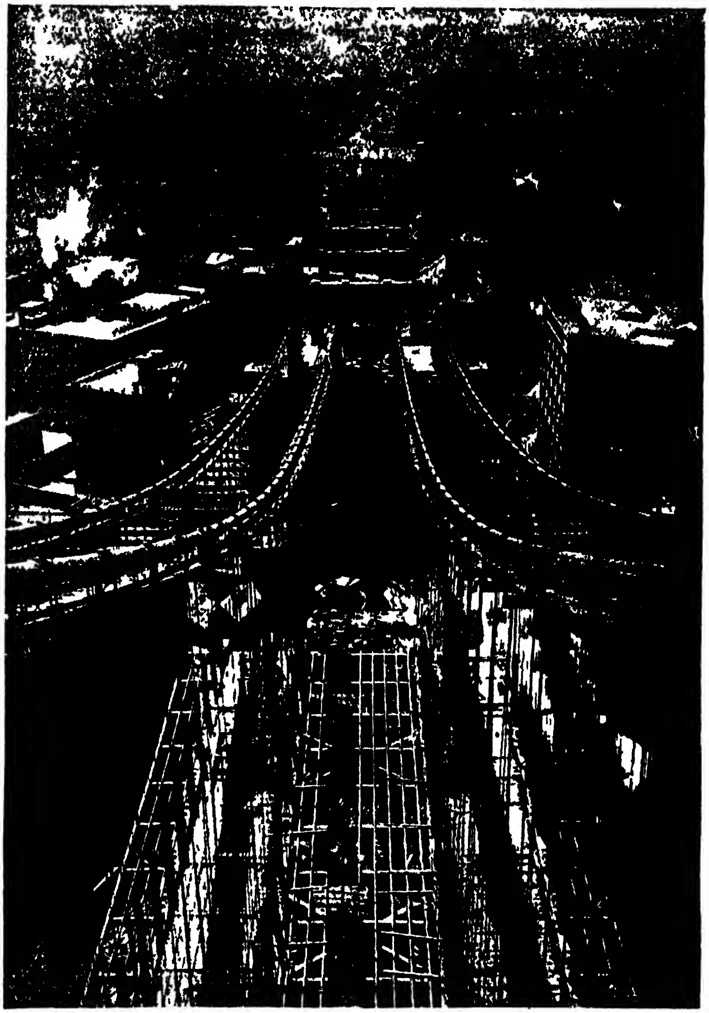
In the building of the Indian bridges, the method usually adopted is that of erecting temporary staging of timber or of iron between the piers, and building the bridge upon this, though it amounts to making a bridge to build the actual bridge upon, and the stagings entail far more trouble and difficulty in construction than the actual bridge does. In India, too, great difficulties arise in consequence of the sudden floods which occur at the time of the monsoons. These floods limit the periods during which

the foundations can be got in and the stagings erected, and they not infrequently come down unexpectedly and sweep away the results of weeks or months of work.

There are two variations in the design of stagings. In one the upright pieces, piles or standards, are equally spaced across the stream. In the other they are grouped or clustered. The difference is that the first interferes with navigation, the other does not. But when there are several spans, one or more may be closed without causing interference. When the cluster system is adopted, the groups of standards have to be connected with horizontal timbers in order to render the erecting platform continuous.

The Attock railway bridge spans the Indus, on the north-west frontier of India, about thirty miles from the Himalayas. It is thrown over a contracted part of the river channel, where the greatest depth at low water is about 30 ft. But in two record floods the water rose 70 ft. and 101 ft. respectively above this level. So in designing the bridge a height of 15 ft. was allowed from the level of the 101 ft. flood to the under side of the bridge. The width of the river at low water at the site that was chosen for the bridge is 600 ft., and a rocky shoal near the centre determined the erection of a pier there. Two spans of 300 ft., each clear, therefore bridge the river at low water, and three of 250 ft., two on one bank and one on the bank opposite, complete the bridge. The different degrees of slope of the banks determined this one-sided arrangement. At flood times, the width of the river extends underneath all the spans to the approaching embankments.

Erection by floating out is largely practised in cases where the conditions forbid the erection of staging, and also in some where it would be practicable, but when for various reasons floating out offers more advantages. It is a method peculiar to iron and steel structures in which a completed girder built on land can be handled and conveyed to its position as one piece. In a tidal stream the rise and fall of the tides affords invaluable help in raising and lowering the pontoons on which the bridge is carried.



LOOKING DOWN ON THE MANHATTAN BRIDGE UNDER CONSTRUCTION

The first bridge for which this method was employed was Stephenson's famous Britannia tubular bridge thrown over the Menai Straits. The story is familiar to most. Briefly, the tubes had to be fixed at a height of 100 ft. above the water in a situation exposed to high gales and without interfering with the navigation. The tubes were put together on shore on a platform 2200 ft. long, built on piles, and containing 110,100

cubic feet of timber. As each tube was completed, it was lifted on six pontoons brought underneath it between the piles, which pontoons, being lifted by the rising tide, floated off the tube. The whole was then pulled out into the stream by means of capstans on shore, and located at the base of the piers. Water was let into the pontoons, lowering them away from the tube, leaving the latter resting on the masonry. Gradually then the tube was lifted with hydraulic jacks, six feet at a time, and the masonry built underneath. On an average, a month was occupied in raising each tube to its position 100 ft. above the stream. When all were in position, they were riveted into one continuous length. The total cost of the appliances and labour for erecting the tubes was £63,380, or £5 9s. per ton of the bridge itself, which weighed 11,647 tons.

Erection by protrusion originated with the practice of building an entire bridge in a continuous length instead of in short lengths of girders to be united subsequently. The idea is attractive, but sufficient counterbalance is necessary, and the strains caused by the overhang are very severe. The first time this was adopted was at Fribourg, in Switzerland, where a railway viaduct crosses the Sarine valley at a height of 250 feet, through which violent gales sweep. The method has been adopted very many times since, sometimes in association with the help of a pontoon. The great advantage obtained is that of low cost, which is but a small fraction of that involved by the use of staging. This, however, only happens when circumstances are favourable, the most essential of which is sufficient rigidity in the bridge to enable it to endure the strains due to the overhang.

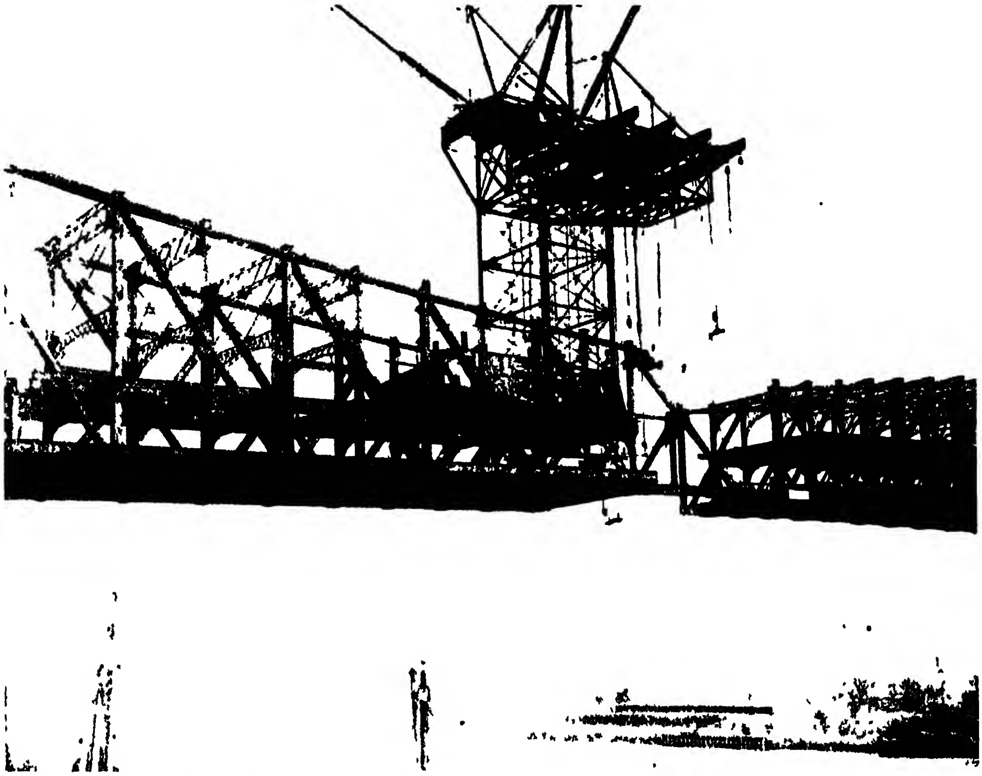
Erection by building out from abutments or from piers was first attempted in Spain in a single arched bridge of 230 ft. span at El Curca, crossing a very deep ravine. The material was wrought iron, and each half of the arch, until they met, formed a cantilever. The method of building the bridge out piece by piece from its abutments has been adopted in many instances since the public were amazed at the boldness of the method when practised at the Forth Bridge.

Another method of erecting is that which is almost exclusively employed for suspension bridges. Wire ropes are got across the river, and by these the suspension chains and links are hauled across, and the bridge erected piecemeal.

No bridge of iron or steel can be built without provision being made for variations in length due to changes in temperature. The simplest method is to fix the bridge at one end only, leaving the other free to move on rollers. Many arched bridges in iron and steel are, as we have seen, pivoted. The chains of large suspension bridges are free to move on rollers on top of the piers. In cantilever and girder bridges, systems of levers are adopted. As much as 24 inches variation was allowed for between the cantilevers and central girders of the Forth Bridge. Compensations by means of levers and links are made on the Tower Bridge.

THE FAMOUS BROOKLYN BRIDGE THAT SPANS EAST RIVER, NEW YORK

A potent cause of bridge failures, in the past more so than in the present, has been the undermining of foundations. The employment of timber-piling was universal for long periods. The elm piles of old London Bridge were undecayed after having lain in the river bed for six centuries and a half. Except for minor work, that method is not adopted to any large extent now. By far the most common system is that of caisson-sinking, though coffer-dams are used for shallow work. The great advantage of the caisson method is that it permits of the employment of compressed air in closed chambers, by means of which excavation can be carried on in the deepest foundations. Another is that the caissons can be sunk lower and lower by their knife-edges, by loading them as the soil is excavated



A SIX HUNDRED-TON TRAVELLING CRANE PLACING INTO POSITION THE LAST SECTION OF MANHATTAN BRIDGE

within. Another is that they can be sunk through any soils, loose or tough, which would present greater difficulties both in piling and with cotter-dams. Practically all deep foundations are taken out now within steel caissons, which are afterwards filled with concrete.

The depth of the foundations of a bridge is governed by the nature of the soil. If a rocky bed is available, that forms a natural basis on which the piers or abutments can be built directly. But loose sand, mud, alluvial deposits, or gravel, however deep they go, must be penetrated and passed until a solid base of rock or stiff clay is reached. These deep foundations often cost nearly as much as the superstructure of the bridge.

PLACING A PIN INTO POSITION ON THE BLACKWELLS ISLAND CANTILEVER BRIDGE

The areas of piers are governed by the load imposed on them by the superstructure and the nature of the soil. It is estimated in tons per square foot, and is higher for rock and stiff clay than for soil of doubtful character. The shape in plan is varied. When there is ample waterway, circular piers are usually built. If the waterway is restricted, or if the currents or tides are very strong, an oblong or an elliptical form is preferred.

In India, where the rivers are often very shallow in the dry season and wide and torrential after heavy rains, a preliminary to bridge-building is the narrowing of the stream to lessen the width of the span. The Sher Shah bridge, near Multan, is an example.

THE GROUPING OF BRITISH INDUSTRIES

Instead of each district in a country manufacturing all the goods it needs and conceivably might manufacture it has been found much more economical to secure subdivision of labour through a rough allotment of separate trades to separate localities, each trade being concentrated—as indicated in the above map diagram—in a special locality with a later free interchange of finished products. This saves much time, labour and capital.

LABOUR AND WEALTH

How the Progressive Economy of Labour is the Only Means of Increasing the Supply of Commodities

THE MACHINE AND THE MAN

We now come to the deeply interesting considerations which attach to the economy of labour.

In the first place, we do well to remind ourselves that the primary object of trade and industry *is not to make work, but to save work.* The conception that the making of work, or the giving of employment, is an end in itself is one of the most hoary of economic fallacies. We must remember, however, that if it is still cherished it is because the saving of labour in an imperfect civilisation is accompanied by loss and suffering to individuals. We must not, therefore, be tempted to regard the subject lightly, and to dismiss with hilarity the master or workman whose circumstances cause him to entertain the delusion.

The fallacy we refer to is often uttered by those who excuse the most luxurious and wasteful expenditure on the grounds that it "makes work." No matter how wanton an extravagance, there are never wanting those ready to make excuses for it on the ground that it gives employment. If the making of work is the end of life, then it is obvious that, the more laborious trade and industry can be made, the better they are for mankind. Why plough, when it would obviously make more work to loosen the soil of a field by digging with a hard stick, or even by pulling its clods to pieces with the fingers? Why use a cart, not to name a railway, when it is obvious that more work would be made by dragging loads over a road by manual labour? Why, indeed, trouble to make a road, when it is obvious that, if the road did not exist, there would be much more work made in moving things about?

When a workman states that he is suffering from lack of work, what he really means is that he is suffering from lack of income, and work presents itself to him as the only means of obtaining the income. We must not wonder, therefore, if the necessity of finding work presents itself to him as the main object of life, and if he is only too prone to entertain the economic fallacy to which we have referred. Indeed, it is not much use to the unemployed workman to remind him that one of the prime objects of civilisation is to reduce the amount of work to be done to produce a given amount of comfort, or a given quantity of utilities. The workman is part of an economic chain which he cannot control, and he is forced only to consider the immediate point, which is how to get a wage. We must not expect him to question the economic bearings of the means by which he earns his wage. The workman may be an exceptionally intelligent man, able to tell you that what most wants doing in his immediate neighbourhood is, let us say, to rehouse people like himself in order to enable them to live decent lives. He may know that economic truth, but of what avail is the knowledge to him? He must find income by obtaining employment; and if, therefore, the work offered him is to assist to build up a luxury, and, in effect, to waste his work from a social point of view, he must needs accept the offer of employment, and he must needs regard the making of work—however foolish, however wasteful, and however absurd—as the immediately desirable thing.

In spite of the castigation of economists and thinkers, the fallacy of making work, therefore, remains current, and is only too likely to do so for a considerable period. Senior, who wrote in the first half of the nineteenth century, very effectively dealt with the subject when he wrote: "Those who maintain that unproductive consumption does good by affording employment must forget that it is not employment, but food, clothing, shelter, and fuel—in short,

the materials of subsistence and comfort—that the labouring classes require. The word 'employment' is merely a concise form of designating toil, trouble, exposure, and fatigue. It is indeed sometimes elliptically used as implying the subsistence which is purchased by enduring it. A poor man complains that he wants WORK. He might work to his heart's content, and with no man's leave, if he chose to carry stones from the bottom to the top of a hill. But what he wants is work as a means of obtaining payment. He would be happy to get the payment without the work.

The Fallacy of Thinking that Work is What Mankind Wants

"Toil, exposure, and fatigue, *per se*, are evils, and the less of them that is required for obtaining a given amount of subsistence and comfort, or, in other words, the greater the facility of obtaining that given amount, the better, cæteris paribus, will be the condition of the labouring classes; indeed, of all classes in the community."

With even greater force, Ruskin, writing as long ago as 1879, and exposing the utterance of the fallacy of "making work," as uttered by the then Lord Bishop of Manchester, wrote, "I cannot easily express the astonishment with which I find a man of your lordship's intelligence taking up the common phrase of 'giving employment,' as if, indeed, labour were the best gift which the rich could bestow on the poor. Of course, every idle vagabond, be he rich or poor, 'gives employment' to some otherwise enough burdened wretch to provide his dinner and clothes for him; and every vicious vagabond, in the destructive power of his vice, gives sorrowful occupation to the energies of resisting and renovating virtue. The idle child who litters its nursery and tears its frock gives employment to the housemaid and seamstress; the idle woman who litters her drawing-room with trinkets, and is ashamed to be seen twice in the same dress, is, in your lordship's view, the enlightened supporter of the arts and manufactures of her country."

The Saving of Labour the Real Road to Wealth

The royal road to wealth is by the saving of labour. The people of the world become grouped and even crowded in those parts of the world in which a definite amount of work can be done with the least amount of labour. That is why, before the days of power-development, fertility was the chief magnet for population, and that is why, again, at a later date, as we saw in former chapters, the discovery of the use of coal drew men to places where cheap fuel helped them to work most easily.

The division of labour has largely and increasingly helped man to economise effort. The distribution of men, of tribes, and even of nations, amongst different occupations naturally arose from the discovery of this great economic truth. We even find the division of labour amongst the higher orders of insects, and amongst men it has existed, in some form, in all recorded history. By following a particular line of effort, one man became an expert carpenter, while another became an expert smith, and each was able to do better work because he stuck to his particular calling. Thus men learned to work for each other, and, by doing so, to save work, and to get more from their efforts than if they each attempted to follow all trades, and each attempted to do everything for himself. Trade, of course, thus had its origin, the division of labour making it necessary to exchange the products of one calling for the products of others.

The Grouping of Trades in Districts as a Means of Economising Labour

Both in ancient and in modern times the division of labour has found expression in the devotion of entire districts to a particular form of industry, the products of which are sent out of the district in exchange for the subsistence of the district. In olden times we found the woollen trade at Norwich, in modern times we find it in Yorkshire and in the South of Scotland and in the West of England. We find the cotton trade almost entirely confined to the county of Lancashire. We find boots chiefly made in Leicester and Northampton and a few smaller towns. We find the cycle trade of the United Kingdom almost entirely concentrated in the single town of Coventry.

The principle of the division of labour is thus very widely practised; and what it amounts to is that a certain amount of labour is saved by the division.

Adam Smith used a very effective illustration of the economy effected by the division of labour. He pointed out that if a smith had to make nails without being used to the job, he would only make 200 or 300 nails a day, and not very good ones into the bargain. With practice, he might learn to make 800 or 1000 nails in a day. But bring up a boy to the nail-making trade, and he could turn out 2300 nails of the same kind in the same time. If Adam Smith lived now, he could take his illustration further,

and point out that, with the aid of suitable machinery, a man, or indeed a boy, can now make tens of thousands of nails in twenty-four hours, by devoting himself exclusively during the day to the same machine.

And it is not only dexterity that is gained by a man who devotes himself to one calling only. A great deal of time is saved, because the pursuit of a particular task saves the time which is lost in changing from one job to another.

The Effects of the Coming of Machinery in Subdividing Callings

Preparing to do work necessarily takes times—the assembling of tools, materials, etc.—and if, therefore, a man did many kinds of work during a day, he would have to waste a lot of his day in preparing for each particular job and clearing up after it.

With the coming of machinery, the division of labour took a new form, and one very far-reaching in its effects. It served to *subdivide callings*, and in many cases to destroy old and honourable employments. The devotion of a man's life to the trade of bootmaking is an example of the division of labour. The breaking up of bootmaking into minute subdivisions, each of which is followed by a particular set of men or women, destroys bootmaking in the old sense altogether, and substitutes a highly complicated organised industry, *the workers in which do not know how to make boots at all.* It is a strange thought that there are tens of thousands of men and women making boots in the United Kingdom today who would be gravelled to know what to do if they had to make a pair of boots from start to finish. The subdivision of the trade goes so far that one man will be found simply smoothing off the edges of the sole of a boot by means of a special machine (which, by the way, is of a most nerve-racking and health-destroying character); while a woman will be found simply sewing up one particular section of a boot-upper, and a young girl will be found simply attaching brass eyelets to the uppers of what is to be a laced-up pair of boots.

The Extraordinary Subdivision of Labour in a Cycle Factory

We see the same extraordinary subdivision if we go into, say, a cycle factory. An enormous press, worked by two men, or even by a man and a boy, is engaged all day long in doing nothing more than turn a specially shaped piece of metal into an oval tubular stay ready for the brazier. The specially shaped piece of metal, we find on inquiry, is cut up by another special machine attended to by another man who does nothing else. The oval tubes, turned out at the rate of many hundreds a day, go off to the brazier, who deals with them, and with them alone, as his special part of the performance. Go into another room, and we find girls fitting up the assembled small parts of a brake. As in the case of the boots, few of these individuals could make you a bicycle, and the complete machine is as much a mystery to them as it is to an outsider in the trade. It may truly be said that although they follow the trade they are engaged in an industry which they do not understand, and that their work is almost unintelligent in character. To see a girl do nothing all day but punch holes in a cycle-wheel rim to make it ready to receive the spokes is to witness an occupation which must become almost purely mechanical. After a time the arms pursue their work almost without the conscious direction of the brain.

The Apparently High Cost of Machines that Make Cheap Things

Sometimes the size or weight of a machine or press devoted to the production of some very small part of a commodity by the modern system of machine production seems almost ludicrous. A press costing many hundreds of pounds may be solely devoted to stamping out bits of metal. The capital so devoted saves an enormous amount of labour, and enables cheap production to be attained. The costly machine at each stroke saves a quite considerable amount of work. Other costly machines do the same service for other small parts of the ultimate commodity. The final outcome is that a complicated article, such as a boot, is produced as the addition of a large number of very small fractions of labour, with consequent great cheapness.

No better illustration of the process can be given than its application to the making of watches and clocks. When, in the early days of the watchmaker's art, a workman of great skill and ingenuity produced an entire watch, the result was a very costly and sometimes a very beautiful and ingenious article, which cost so much in labour that it could only be enjoyed by a few. A king, a nobleman, or a rich merchant might possess such an object with some difficulty, for the wonder of the world at large. Later, when there was some amount of division of labour introduced, as in the justly celebrated Swiss watch industry, a watch came into existence which could be afforded even by the middle class. Nowadays watches can be

produced at so low a cost that they can be retailed at 5s., or less, and they can be bought new by boys and girls. These quite efficient articles are produced by stamping out the various parts by separate machines, and putting those easily made parts together. The result is a standard article, each of the parts of which is interchangeable with each of the smaller parts of any other of the hundreds of thousands of watches of the same kind produced.

The Cheapening of the Motor-Car by Standardisation and Machine Manufacture

In the last few years the same principle has been applied by the Americans to the making of what was only lately a great luxury, the motor-car. If you apply division of labour as it was understood by Adam Smith to the making of a motor-car, you get a very costly article indeed, one which could not be produced under some thousands of pounds. With the aid of good machinery, but still adhering to the building of a car as an individual thing, the cost can be reduced to something in hundreds of pounds. The Americans have applied to the motor-car the same principle of standardisation which they introduced for the boot industry; and we find them turning out thousands of cars of the same pattern, each of the separate parts of which has been produced under the system of extreme division of labour. As a consequence, we find them offering cars at what seems an extraordinarily low price, but which is not extraordinary in view of the economic method of production.

Throughout the practice of the division of labour it is apparent that there runs the principle of increasing wealth by saving labour; and this is as true of the old and simpler form of the process, which saw craftsmen engaged in carrying out in its entirety the manufacture of an article, as it is of the later form, in which one kind of manufacture is split up into many tiny individual operations.

The Recentness of the Machine Age, and its Great Influence on Human Society

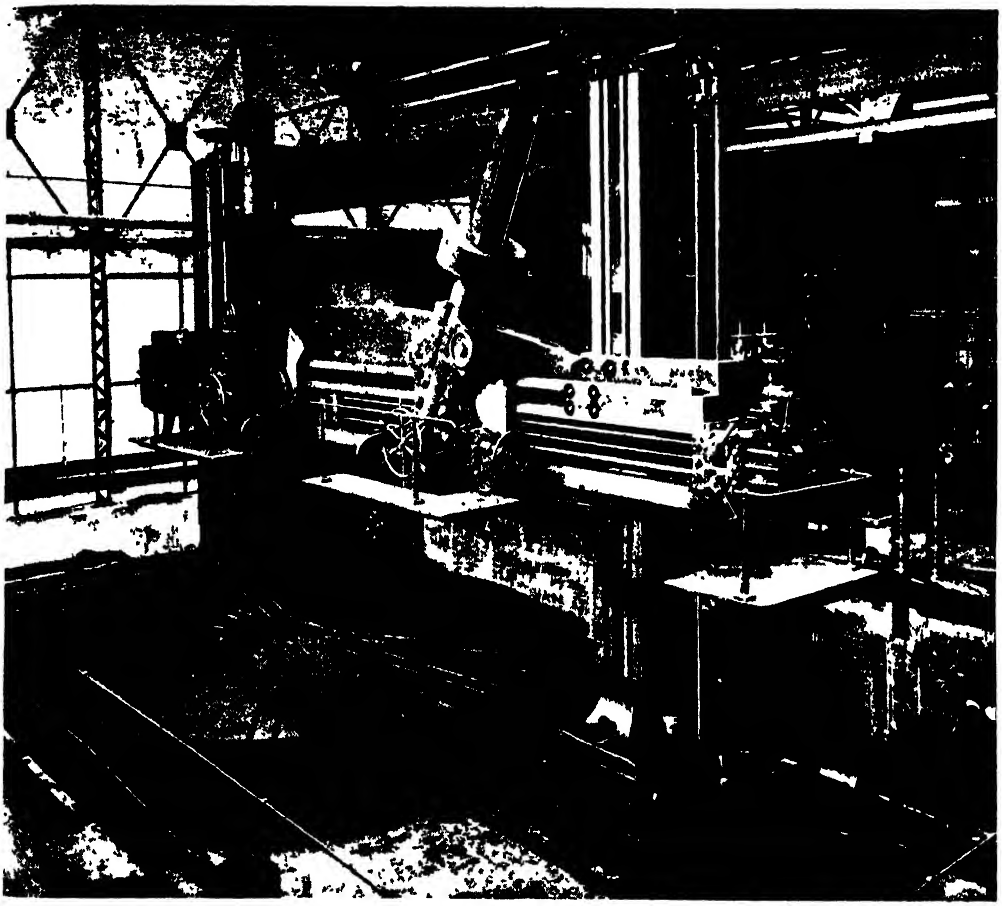
The inventor thus presents himself as a saver of labour, and since the beginning of the second half of the eighteenth century he has worked marvels in this direction. The machines were first supplied with great advantage to the textile industries. It was in 1764 that Hargreaves introduced the spinning-jenny. By and by there came the power-loom, and more than a hundred years have now elapsed since the hand-weavers' trade passed away. In 1769, Watt took out his steam-engine patent and by 1781 he had made steam-working effective. As we have already seen, the steam-engine was really called into existence by the necessity to pump coal-mines. In 1807, steam was first used in navigation, and it was in 1825 that the Stockton-Darlington railway was opened. In 1838, Brunel's "Great Western" crossed the Atlantic; and in 1831 Faraday discovered magneto-electric induction, the first discovery of the electric current or of galvanism having been made by Galvano on the threshold of the nineteenth century. We name these dates to remind the reader how short a period separates us from the realisation by man of the powers which he now commands. It is a span of time which counts for nothing in known history, but yet it is a period long enough to count for the passing of five or six generations, and to produce in the character both of individuals and of society a very considerable effect.

The Complexity of the Machinery of Life under Modern Divisions of Labour

Closely allied in nature to the introduction of machinery into a business is the organisation of trades as a whole. Just as we save labour by applying machinery to enable one man to do as much work as many men could do without the machine, so we save labour by uniting the small, scattered units of a business, bringing them under one control, and eliminating all duplications of effort. This process, with which we shall have occasion later to deal at greater length, has gone far in connection with not a few industries.

As we have already noted, trade took its origin in the division of labour. As soon as men ceased to do everything for themselves, and divided up occupations between different families or groups, it became necessary to make exchanges in order to secure a varied subsistence. We see a modern community so divided and subdivided that it is true to say that not only does one half not know how the other half lives, but that few indeed of the individuals concerned pause to consider the working of the community as a whole, or the relation of their own share of work to the aggregate of the community's work. The average man does not stop to consider the extraordinary complexity of the organisation which feeds him and clothes him and supplies him with comforts in exchange for some contribution, large or small, made towards the general fund of wealth. It is true not only of the average workman,

but even of the great manufacturer or merchant, that, however intimate he may be with the particular groove in which he himself carries on his operations, he has little grasp of the scheme of things entire. In the old days it was easier to grasp the machinery of life. Foreign trade was very small in dimensions; and for the individual it was easy enough to understand the exchanges that took place in the small market town surrounded by an agricultural belt. The farmers took their produce to market, and found in the city the simple arts which mainly made up the economic balance. Today the population is congregated chiefly in large towns; and in these the complexity of economic forces hides the real nature and effect of transactions, and leaves the "man in the street" largely ignorant of the world. The shops in the towns sell articles which more often than not are made in places remote, and the modern shopkeeper does not always know the real nature of the articles which he sells. The area of the division of labour has, of course, widened with invention. The railway and the steamship have done more for trade than any other third cause, and at each stage of their expansion they have widened the area of exchange. In the old days the butcher's shop was a place in which was retailed the meat of animals raised in the vicinity. Transport next made it possible for people to eat meat grown at a considerable distance, and, combined with cold-storage, has now actually made it possible for the Old World to eat the flesh of animals raised in the New World. No more striking instance than this could be given of the fruits of the division of labour. It has been pointed out by Professor J. R. Commons, in connection with the American meat trade, that the ox has been "surveyed and laid off like a map." The American butchers have been classified in over thirty varieties, and there are twenty different rates of pay,



A STUPENDOUS LABOUR-SAVING MACHINE IN A MODERN TURNING-SHOP

ranging from eightpence to over two shillings an hour. "The 59 cent man is restricted to using the knife on the most delicate parts of the hide (floorman), or to using the axe in splitting the backbone (splitter); and wherever a less skilled man can be slipped in at 18 cents, 18½ cents, 20 cents, 21 cents, 22½ cents, 24 cents, 25 cents, and so on, a place is made for him, and an occupation mapped out. In working on the hide alone there are nine positions, at eight different rates of pay. A 20 cent man pulls off the tail, a 22½ cent man pounds off another part where good leather is not found, and the knife of the 40 cent man cuts a different texture and has a different 'feel' from that of the 50 cent man. Skill has become specialised to fit the anatomy." So the animals of America are divided up by specialised gangs, and the varied products are sent to the ends of the earth through the art of the inventor.

The International Division of Labour, and the Exchanges to which it Leads

This brings us to the *international division of labour*, which is only another branch of that geographical division of labour at which we have already glanced. Within our own country we find one district doing one kind of work, and another district devoted to an entirely different occupation. It is not surprising, therefore, that as between one country and another we find a considerable variation of products. This partly arises from variation of natural gifts. A country rich in power is naturally a manufacturing country. A country rich in fertility is naturally an agricultural country.

Just as a nation gains by the different parts of it being devoted to different occupations, exchanging with each other the products of their labour, so a country gains when its people, producing with facility and abundance certain commodities for which it is particularly suited, exchanges those commodities for the products of other lands which have different advantages. In former chapters we have seen what an enormous trade is done by the people of the United Kingdom in exchanging the products of their manufacturing powers for the diversified products of the entire globe, and we have realised that if these exchanges had not been brought about it would have been impossible for the United Kingdom to maintain so great a population.

It is important to observe that international exchanges rest upon three very different bases, and that two of these are permanent and the other not necessarily so.

The first permanent basis is the wide differences which exist in the natural resources of different parts of the world. England has plenty of coal and no sulphur, Italy has plenty of sulphur and no coal.

International Division of Labour Based on Differences in Natural Resources

These are unalterable facts, and as long as coal is useful, Italy will have to get coal, if she needs it, by exporting something which she possesses -say, sulphur or oil—in exchange for it. Similarly, England possesses no sulphur, and must get what she needs of it by exchanges with Italy or some other country which produces it. Again the fact is unalterable. A very large part of the trade of the world rests upon such unalterable facts. The English climate does not allow us to produce mahogany, or teak, or indiarubber, or gutta-percha, or ivory, or mangoes, or cotton, or hemp, or jute, or cocoa, or coffee, or tea, or oranges, or lemons, or wines, or a host of other things that might be named. With regard to these, we shall always have to rely upon supplies won by commerce; and so also it is with the many minerals and metals which our soil either does not produce at all or produces insufficiently for our needs.

The second permanent basis of international trade is found in differences of race-genius as between the peoples of different countries. These differences are sometimes great and obvious, sometimes slight and subtle, but they have a very great influence upon the causation of trade.

How Race-Genius and Acquired Skill Affect Division of Labour

We find the people, or part of the people, of a particular country possessing some gift which enables them to excel in a particular branch of work, or to add to it something which gives it individual character and value. Here, again, we are confronted with what may be termed an unalterable basis for trade.

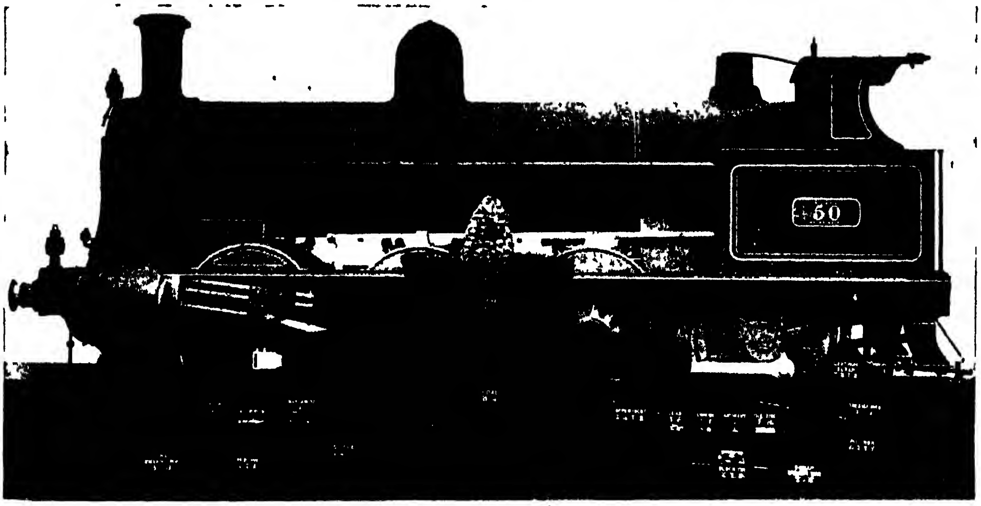
The third basis of trade is acquired skill; and here we have something which, as time has already shown, is a very uncertain basis for the exchange of commodities. Sometimes, by obtaining a start in a particular industry, as Lancashire did through the invention of Hargreaves, Crompton, Arkwright, and others, the people of a district seem to acquire a particular talent for handling it. For reasons which are sometimes obvious, sometimes obscure, special skill in particular industries is

acquired by the people of certain districts; and when once an industry has obtained a special organisation and concentration in a district, it acquires strength by virtue of the fact, coming to possess facilities for obtaining material, labour, etc., which enable its members to work with advantage. There is no absolute permanency in such organisations, however; and it does not follow that, because a certain town in the world possesses at this time a strong trade position, it will for ever continue to hold it. Nothing is more puzzling than the concentration of industries at particular points. Take, for example, the lace industry of Nottingham, the boot industry of Northampton, or the cycle industry of Coventry. In these three cases, and in others that might be named, there is no good reason why the trade should be carried on in these towns rather than in others, and it is clear, therefore, that those working in them can only maintain their position by unremitting skill and enterprise.

It is clear that so far as trade rests upon the third basis we have named—that of acquired skill—there is no permanent basis for trade; and town A in country B, which at present does a fine export trade in a particular article with, say, Australia, may find Australia herself come to possess equal or even more skill in the production of that identical article.

Other things being equal, the division of labour must lead to industries being carried on in those parts of the world best suited to them—*i.e.*, near power, or near materials. We cannot wonder that a wool-producing country like Australia or New Zealand should aspire to manufacture its own woollen goods instead of exporting its fleeces to be worked upon at the other side of the world and returned to it in a manufactured form. We cannot wonder that wood-pulp should be largely made in places where the timber out of which it is made is grown. Only lack of power can ultimately prevent the material being worked up in the place where it is produced; and when the world's water-power is developed, or if new sources of power are discovered, we may see very great changes take place as the result of the further great division of labour.

It is only the setting free of labour by its economisation that enables new tasks to be undertaken. If the raising of food was so laborious as to occupy nearly all the time of the human race, then men and women would be able to command little else but food. As soon as food-raising becomes simpler, a certain number of workers are set free to make homes and to make clothes. As soon, again, as these tasks are lightened, a certain number of people become free to supply further comforts. Summing up what we have considered in this and the preceding chapter, we see that labour is saved and set free by continuous processes which may be briefly expressed as follows.



A SUBSTITUTE FOR LABOUR BUILT FROM THE EARTH'S RESOURCES BY LABOUR—A LOCOMOTIVE OF 50 TONS AND THE 139 TONS OF RAW MATERIALS WHICH GO TO MAKE IT

This London and North-Western goods locomotive stands behind the following materials that are used in its manufacture.

	Tons	cwt.	qrs.	lb.
Coal	57	10	0	0
Steel scrap	8	[illegible]	3	15
Iron ore	24	4	0	7
Pig iron	7	6	0	0
Swedish iron	6	9	0	0

	Tons	cwt.	qrs.	lb.
Copper ingot	4	19	1	21
Coke	4	12	0	[illegible]
Spiegel	2	19	3	17
Cast iron scrap	1	10	1	15

	Tons	cwt.	qrs.	lb.
Limestone	0	18	1	1
Block tin	0	4	3	14
Lead	0	[illegible]	2	27
[illegible]	0		[illegible]	[illegible]

	Tons	cwt.	qrs.	lb.
Phosphor copper	0	0	2	14
Ferro manganese	0	1	0	20
[illegible]	0	1	[illegible]	

	Tons	cwt.	qrs.	lb.
Chrome	0	0	1	
Aluminium	0	0	0	1
Antimony	[illegible]	0	0	1
Total	139	18	1	

1. The storing of labour as capital or stock;

2. The division of labour;

3. The invention of new machinery and processes;

4. The exchange of commodities, which has its roots in the division of labour.

It is important to observe that what we have termed the setting free of labour by the saving of labour need not cause unemployment or distress to any man, but may easily do so through lack of social and industrial organisation.

Consider a simple case, that of the cycle which we have already mentioned. When the cycle was first introduced it was very costly, and it could only, therefore, be ridden by well-to-do or fairly well-to-do people. Twenty-five years ago, a good bicycle, with all the latest improvements, cost £25, a sum quite out of the reach of a workman. As a consequence, poor people were quite unable to ride bicycles, and their consumption, even by the middle classes, was small. Bicycles were dear because so much labour had to be expended in their production.

Since then the new method of production, with minute subdivision of labour to which we have already referred, has been introduced; and as a consequence we can buy in 1912 for £8 or £10 a bicycle which is not only as good as, but better than, that which was sold for £25 twenty-five years ago. We say better, because it includes many inventions and improvements which had not been thought of twenty-five years ago. A very good bicycle can now be sold wholesale for £2 10s. or £3, and retail for £4 or £5; and such a bicycle, second-hand, can be bought for 30s. Consequently, workmen now commonly ride bicycles; and the motor-bicycle can be bought at not very much more than a first-class ordinary bicycle or tricycle cost in 1885.

What has been the effect upon labour? At first sight it would seem that there would be a loss of employment, but what has happened is quite the reverse. The number of men employed in the cycle trade has considerably increased, and is much larger today than it was twenty-five years ago, the reason being that the cheapening of production has so greatly increased the market for bicycles that an enormously larger number of machines is wanted. Instead of invention reducing the number of people employed, it has increased it.

That remains true up to the point of what may be termed saturation—up to the point at which the possibilities of increasing the market by cheapening production ceases. As from that point, it is clear that a further saving of labour in the trade must reduce the number of men employed in it.

Is it, then, a good thing or a bad thing that in a particular trade—say, the cycle-making—invention should be carried so far that all the cycles which the community can possibly require can be made by a very small number of men? A moment's reflection will show that it is a most desirable thing, and for this reason: if fewer men are needed to make cycles, or any other given commodity, *then a certain number of men are set free to take up new work.* It is only by freeing labour from old occupations in this way that the community can gain new trades and enjoy new comforts.

Let us suppose that in a given community of a million people there are ten different occupations, and let us distinguish these by the letters A to J. Let us suppose, further, that the members of this community, working economically by known methods, are divided up in the following proportions between the ten trades.

Trade.	Number of Workers
A	100,000
B	50,000
C	125,000
D	200,000
E	75,000
F	50,000
G	50,000
H	300,000
I	25,000
J	25,000
All ten trades	1,000,000

Now let us suppose the community of a million persons to increase to five million and let us suppose, further, that while the population so increased no labour was saved in any of the ten occupations, and that, therefore, each of the ten trades had to employ the same *proportion* of the community as when the community numbered only a million people. Then, when the community reached five million persons, the division of occupations would be as follows

Trade.	Number of Workers.
A	500,000
B	250,000
C	625,000
D	1,000,000
E	375,000
F	250,000
G	250,000
H	1,500,000
I	125,000
J	125,000
All ten trades	5,000,000

What does this mean? It means that, although the community has multiplied five times, it cannot be a farthing better off per individual, because no labour has been saved, and exactly the same proportion of workers is needed for each trade. Not a single new trade can come into existence, because a new trade under the circumstances can only be gained by giving up an old one or part of an old one. No matter how sorely other industries, which we will call K, L, and M, may be needed, they cannot be started, because there is not a single worker free to engage in them.

The Difficulties of Starting a New Industry in an Old Country

It comes to this: that a new industry can be started in a country only by freeing labour from an old industry.

Every inventor, therefore, who displaces labour is a servant of mankind. Every business organiser who shows how one man can do the work which two men used to do increases the wealth of the world.

But while all this is true, it is also true that for a specific individual a new invention may spell disaster and ruin. If to-morrow an inventor were to produce a painting-machine which would apply paint to wood or other work as well as it could be done by hand, but with only one-twentieth the amount of labour, then a very large number of painters would be thrown out of work, and they would suffer severely. The cheapening of painting would lead to more painting being done, and this fact would re absorb some of the displaced labour. The community as a whole would benefit considerably; and children growing up into new workers, not being required so much for the painting trade, would be able to engage in new occupations. But a certain number of aged or ageing painters would permanently suffer, and in some cases might even be reduced to want and beggary.

The Loss to the Individual by Changes Beneficial to the Community

We have seen the process going on before our eyes in connection with the cab trade. The motor-cab has been very suddenly introduced; and as it is a class of work very different from driving a horse, many aged and ageing cabmen have had their old trade taken away, without being able to break themselves to the new one. As a consequence, there has been suffering for many individuals.

We see, therefore, that while it is quite necessary for the progress of society, and for the increase of the wealth and comfort of the community, for labour to be continuously and progressively displaced and set free to engage in new occupations, what is on the whole and in the long run a beneficent process is attended for a minority of individuals by quite undeserved loss and, possibly, acute suffering.

If the community as a whole thoroughly understood the importance of the matters of which we have been speaking, it is surely clear (1) that they could not stand in the way of new inventions, and (2) that they would see to it that there should be no individual loss through the application of new inventions. It is not impossible, it is not even difficult, to make social and industrial arrangements by virtue of which men who are thrown out of their trade by the march of invention may be tided over until they can find a new employment.

When our organisation has reached a higher degree of development, the essential truth that the object of trade and of industry is not to make work but to create a plentifulness of utilities with the least possible amount of work will be realised, and, when it is realised, few difficulties will stand in the way of its accomplishment.

The Way by which Mankind May Escape from the Tyranny of the Machine

Nothing can ever make the attendance upon machinery a task fit to be prolonged for many hours at a time. How, then, is civilisation to cure itself of the evils which can so easily arise from the use of machinery? How is it to retain the advantage of cheap production while obtaining for the individual a proper recreation of faculties?

The answer appears to be that, when work comes to be thoroughly organised, what machine-work will be necessary will be so devised and so distributed that no member of the community will be reduced to the rank of a machine-minder for any considerable length of time. We cannot abolish the machine; it would be foolish to abolish the machine. Civilisation must, however, abolish the machine slave; it must banish such pictures as that of a young girl punching for nine hours a day, and for five and a half days a week, holes in the rims of cycle-wheels. Attendance upon machines would be a different matter if it were so reduced to a thorough economy, and so shared as a social duty, that no man or woman had to do more than man or woman can bear without losing well-being.

HOMES THAT HAVE FALLEN ON EVIL DAYS

SCENES FROM THE LIVES OF THE POOR WHEN SICKNESS HAS PROSTRATED THE BREAD-WINNE

PUBLIC HEALTH TO COME

A Plea for the Complete Organisation of the Health of the Whole Nation, from Birth to Death

DUTIES THAT SOCIETY CANNOT ESCAPE

In our last number we reviewed the story of the growth of a public consciousness that health is a collective concern, and must be dealt with legislatively and administratively for the physical and financial good of all. Such a consciousness came very slowly, but it is now expressed in many Acts of Parliament, which are strengthened greatly as each decade passes. We brought the story of that late but rapid growth to the threshold of the future, and there left it. Something more remains to be said here in answer to questions then raised, though several of the answers we shall give were briefly indicated. Our historical story contained material for thoughtful opinion, and for some serious lessons which we wish to drive home before passing away from the subject. The responsibility of society as a whole for health as a whole, and at all times, is one of the new collective duties that many at first sight will regard as burdens, but that others will see taking shape as blessings at no distant date. In any case, it is well to turn over the materials for a deliberate judgment.

"If there be no vision, the people perish" is deeply true, no doubt, but an obstinate distrust of vision is embedded in the average British nature; and it is more effective to prove that a thing pays, and is cheap, than to prove that it is wise. Happily, in the case of public care for public health, economy is the most obvious argument as soon as anyone begins to think on the question at all. Individually and nationally, health is wealth and sickness poverty. Every man, woman, and child who is ill is draining the resources of the family, and often of the nation, for as a last expedient many have to be kept by the nation; and long before that time comes ill-health has had a crippling effect.

The moment a man stops his work, not for the sake of rendering himself more efficient by a holiday, but because he is already below a normal standard of efficiency and must be brought back to it, he is a loss to the community; and the loss deepens with the severity of the illness, till it becomes absolute in death. What is the economic value of an efficient worker that may be lost by death? That is a question which an advertising community like Canada knows quite well. It can afford to send its emissaries forth all over Europe, gathering in desirable immigrants at a considerable cost, because each is worth a thousand dollars on the average to the country he settles in, though he may arrive poor. The preventable death of every able man in a country is a sheer loss of human capital.

Look at the details of that approaching loss when ill-health causes a man's activities to cease. Who has not seen the state of a family that has an ailing father? The subsistence of the whole household is lowered, and its efficiency temporarily, or perhaps permanently, impaired. The children are less well fed, and show it in weakened health and lagging education. Though the family may "carry on," through friendly society help, it is with a life slackened and slow-timed, and all the while the friendly society is being itself weakened, so that there comes a time when its payments must cease. Then the man's home suffers further; the furniture is thinned; social status is lost in the midst of the working classes; relatives and friends are financially drained by the help they give; and eventually the cost of the illness probably falls upon the whole community, or a part of the provision for the children and widow if the man dies. This process is being repeated everywhere, and insurance will only palliate and will not preclude it. Could anything be more uneconomical than allowing it to exist if public care for health will largely remove it?

But the case is much worse than has been stated. If the man who is ill recovers, but remains weakly, as may well be the case if his illness was caused by unhealthy conditions which continue, he ceases to be a fully efficient worker whose services are in immediate request. In these days of speeded-up labour, a sharp line of division is drawn between the men who are alert and "fit" and those who are not. The less active are the first to be dismissed when work becomes slack, and they are the last to be re-engaged when trade revives. The result is that the man who has been ill, and is struggling towards full recovery, is handicapped by a want of chances as well as a want of strength.

Nay, more; he is handicapped by his own waning skill. The managers of great modern "works" say, with firm decision, that withdrawal from work for any cause very seriously impairs high efficiency. Their proof rests upon the cases of men who were allowed leave to go with the Volunteer companies to the South African War. Many of the men who went were of a fine type, from the point of view of efficiency as workers. When they returned they could not, in many cases, resume their former duties, though in physique they were improved rather than impaired.

Results of Disease—Startling Monetary Loss, Suffering Untold, and Danger Menacing All

If this deterioration in workmanship occurs under such conditions, how much more likely is it to occur when absence is caused by illness, with its accompanying weakness and loss of nerve?

Surveying the whole range of illness from the point of view of economy, financial and physical, do we not see how enormous must be the family loss, and the civic and national loss? It would capitalise into most startling figures, that would make the cost of ameliorative or preventive measures look small and mean. And this loss, unquestionably, might be vastly reduced by more fully organised attention to the general health by the determination that the conditions which cause this ill-health, whatever they are and however they are supported, simply shall not be allowed, but shall be altered as quickly as possible.

We are purposely confining to the briefest mention the humane and the cautionary aspects of the question. The enormous amount of suffering, of pain, anxiety, and privation caused by preventable disease will not tolerate any exercise of imagination in realising the facts it is too terrible. Then there is the appeal made to everybody's sense of self-preservation by the certainty that far more disease is infectious than our forefathers ever suspected. The continued existence of disease that must spread if it is allowed at large is a menace to all which approaches very near to the region of crime.

Of all the claims put forward by modern science, none is more convincingly supported by proofs than this—that the spread of disease is not inevitable, and, indeed, that the very existence of many forms of disease is not inevitable. That is one of the great messages of hope announced, with the utmost confidence, by present-day discovery.

The Modern Proofs that Disease may be Largely Banished

Such confidence is warranted by the final test of plain facts. Under the sanitary conditions which have already been imposed after strenuous controversy and labour many diseases have been practically extirpated, and the health of whole communities and nations has been improved beyond the dreams of pioneer visionaries. Malaria has been so completely conquered, where it has been tackled scientifically, that death-trap districts have become positively healthy; ague has practically disappeared; and various "fevers" which decimated the population a hundred and fifty years ago are now quite outside of the experiences of many medical practitioners. It is within the memory and personal knowledge of the present writer that twelve female heads of families out of a certain group of fifteen houses in a low lying, damp district were habitual users of opium; and there were excuses why it should be so. That state of things is disappearing, if it has not already vanished and the health statistics of the whole nation have improved so enormously as to repay many times over, the comparatively small cost of sanitary science.

People whose Lives are Three Times as Cheap as Those of Their Neighbours

If the proof of figures is needed it can be found in the returns of the Medical Officer of Health for any city or borough in the land comparing one registration district with another. The story is universal. In the suburban districts, where there is plenty of space, fresh air, no overcrowding, and a fair degree of intelligent regard for healthy surroundings, the death-rate will vary between eight and twelve per annum per thousand of the population. But, on the other hand, where there are narrow poisoned streets and courts, fœtid, ill

provided with sanitary appliances, unflushed by air, and continuously overcrowded, with the public-house as the popular place of social recreation, the death-rate is habitually high. The drama of life and death told in these figures is constantly acted under our eyes, month by month, if we will but lift our eyes and see it.

The Effects of State Medicine Upon the Medical Profession

The education of all classes of people in the broad, simple facts of public health, and the economy these facts suggest, is perhaps the most immediate want, for little can be done without the backing of public opinion. For, first, there must be fought the two objections that any comprehensive treatment of the question of health may be detrimental to the medical profession; and besides, it all means doing something for people who ought to help themselves, and so spoiling them in character. So the old story will be retold of quarrels as to the means of doing good things rather than getting about doing them.

No doubt any advance in the preservation of public health by public means, controlled largely on official lines, will cause a considerable amount of dislocation in medical practice. There will be fewer doctors who are not officially employed attending all except the people who prefer to pay for the special attention of their own doctor; and the change from individual enterprise to public service on the part of many will be accompanied by some of the hardships that are inseparable from social and industrial development. Such adaptations are constantly demanded from men engaged in business and industry, and doctors will have to accept them. The changes will not, however, be so considerable as many might suppose, for the number of doctors engaged already on public or semi-public duty is very large, much larger than is admitted by members of the profession who make it their business to resist the inevitable; and the end will be a great relaxation of the strain of competition.

The Impossibility of the Average Individual Securing Healthy Conditions for Himself

The reply to those who object to public health being made a collective responsibility is that under modern conditions of life no one can command for himself healthy surroundings unless he seeks the poetical "lodge in some vast wilderness." The safety of each is bound up with the safety of all. We can help ourselves better through the common stock of good than by making the health conditions of our home, place of business, or residential centre an individual matter. Besides, we are already committed deeply to the preservation of the general health out of the rates and taxes; and the further progress of the movement only means the efficient doing of what we are already committed to, and what is bound to go on to a comprehensive completion.

What, then, is it that can be done to reap the full fruits of sanitary science? The reply is that the State can undertake the supervision of the health of the whole community from the beginning to the end of life. The method of it is already outlined and brought into practice, with some gaps of administration possibly, in almost any British city that is up to date in its public health, school, hospital, insurance, and poor-law work. Only a little extension of operations, and catching up of loose ends, and the organisation would be completely framed.

Examples of State Care for the General Health Already in Active Operation

For see what is already done where existing laws are sincerely and energetically worked. Before a child is born, the women members of the staff of the Medical Officer of Health are on the look-out to see that it has a fair chance of continued life in health. The maternity lectures, and the advisory medical treatment of ailing infants, so largely in vogue, have popularised this branch of public service; and the maternity benefits of the Insurance Act will give a fresh stimulus to the work of medical departments. The child now comes under the eye of the authorities from the day of its birth; and notification of all illnesses ought to accompany it to old age, for the public benefit as well as for individual advantage. Once on the books of a school, the regulation is strict against the child being taken off unless it passes directly to another school. For example, a child that is ill for six months, and not attending any school during that period, may not be removed from the books of the school it last attended—a most admirable regulation which secures that the national count of the child as a member of the community shall never be lost.

It is true that, with the incredible perversity of Education Departments, this absence of the child is used to deprive the school of the grant. The place of the child in the school may not be filled, but the place is not paid for. The Department, in short, offers a monetary inducement in favour of a breach of its own salutary regulations.

But that is the way of Departments till their folly has been often exposed. The net result is that the numbered children are known. They are lined up by the nation, recorded, registered, examined, and, to a growing extent, doctored when they need it.

In some cases a considerable number of special ailments are dealt with directly by the medical staff, or specialists, in relief of hospital treatment. The ordinary procedure is that, when a child is found through medical inspection to be in need of treatment, a note is sent to the parents, who are advised to consult their medical man. But if poverty is pleaded, and a wish expressed for treatment by the Authority's specialist, such treatment is given. In this way each child, in some cities, is tested for tuberculosis by modern methods; and defects of vision and of teeth, diseases of the ears and throat, and diseases of the skin, are all treated curatively; and in one way or another, either by the intelligent concern of parents or through the public service of the official medical staff, about half the children found to be in need of treatment actually secure it.

The Gaps in Health Supervision by the State

But what of the other half? It is quite clear that, with insurance responsibilities coming along, means will have to be devised for prompt attention to childish weaknesses. Again and again during school life the whole area of childish disease, in any community that has efficient medical school inspection, is mapped out. It cannot long be known and neglected, in face of the proved costliness of the diseases begun in childhood, and prolonged so as to paralyse manhood or womanhood in mid-life.

Further, under the Choice of Employment Act, as originally drafted—though it has been mangled by compromise agreements between warring Government Departments --arrangements were contemplated by which the school authorities should keep a register and record of their children till they are of an age to come under the Insurance Act, when health preservation will assume something like a national character, and continue to the days of the Old Age Pension.

Where are the gaps in this framework for the treatment of a nation's health? They come between the infant in arms and the child of school age; between the child of school age and the young person of insurance age; and the framework does not include a multitude who are neither registered in schools nor yet in insurance proposals. Besides, where ill-health is discovered and well known, there is no fully organised method of treatment. Indeed, tuberculosis of an infectious nature may be widespread, and yet no steps be taken either to help the patient or prevent him becoming a source of further disease. How long will this state of things be allowed to exist? Is not the time at hand when the whole community will treat all communicable disease as *its* affair, and not the private concern only of the person affected?

The Need for a Natural All-Inclusive Health Register

The first step is a health register of every person in the land. An inclusive register can be compiled readily when taxes or rates are the subjects of inquiry. Why should there not be a complete health survey in the interests alike of public safety and of the welfare of the individual citizen? Such a register kept for a few years would reveal some startling facts, the knowledge of which is essential to the wise public treatment of disease, and the prevention of its unrestricted propagation.

For example, it would disclose, in the most sensational way, what all close observers of the slum life of cities are aware of that poverty, disease, and crime, and the conditions under which poverty, disease, and crime thrive, are distinctly bred in what may be called a class. Of course, we do not say they are exclusively bred in a class, but they are predominantly bred in a recognisable clique or circle.

In saying this we are not raising a distinction between what is called the working class and the rest of the community.

The True Working Class, and the Slum Clique Within but not of it

Large sections of the working class form, perhaps, the most thrifty, intelligent, aspiring, and in every way worthy social aggregation. They are straightforward, sincere, genuinely virtuous, and the enemies of all pretension and sham. They form a reservoir of human character from which the stoutest manhood of the nation is perpetually recruited for the pushing forward of the world's progress. But within the true working class, yet not of it, there is a degenerate breed, that all workers on poor-law lines are aware of, which has never been lined up, examined, and duly registered by society with all its potentialities for evil rather than for good—a class that is being constantly recruited by degenerates from higher social layers.

WHERE A BETTER CHANCE IS NEEDED

[illegible]ESSING CONDITIONS IN THE LIFE OF THE COMING RACE IN STREET, SLUM AND SCHOOL

It is this class, or clique, into which the genuine working class dread to fall, and with whom they will not readily associate—the slum folk. To know the realities of their life through successive generations, it would be well to consult, say, experienced Guardians of the Poor, who have long toiled at relief work in detail, and with them the relieving officers, the school-attendance officers, and the special police who are entrusted with the protective supervision of child-life. Men of this type know the breeding of the slum poor for three or four generations, and they know that feeble-mindedness, disease, and crime, with poverty and alcoholism as almost certain accompaniments, are grown, a fruitful and scarcely varying crop, which will never be eradicated until the health problem is faced consistently and nationally. These slum people, living in a state of filth and verminousness that cannot be described in print, make in every city a seed-bed for disease, and the whole community suffers for its sin of negligence and aloofness from the facts.

The Uncleansed Residuum Left Over from Backward Times

The moment this collection of disease breeders and carriers—of which tramps are a wandering variety—is mentioned certain listeners turn away in hopeless disgust, and others settle the matter to their own satisfaction by accounting for the phenomenon. These latter say the degenerate type are made degenerate by their slum surroundings. That is only partly true. Many of them are lineal survivors from the bad days of disease, penury, and misery, when the industrial system was built up without humanity, and sanitary science had not been formulated, nor public health legislatively cared for. But, however they come, they are here, and society has to deal with them, for the sake of their own health, and that of the community of which they form a part; and, whatever the origins of slum life may be, whether they be found in neglect by property-owners or in the inherent weaknesses of degenerate human stocks, the existing condition of things cannot be continued by any self-respecting and self-protective people.

Sooner or later, the State, for the common good, must take care of the people who cannot take care of themselves, and are a danger to all. Whatever the cost of such guardianship may be, it will have to be undertaken. If better housing is required, it must be insisted on, with prohibition of overcrowding; but putting up buildings will not command sanitary conditions, nor abundance of light, nor readiness of access to a plentiful water-supply, nor sound paving, nor swift removal of refuse, though all these things are essential, as preliminaries to general good health. There must be authoritative inspection to see that cleanliness is observed within the houses, and that sanitary conditions are preserved.

The Modern Augean Stable which Society Must Cleanse

The so-called "homes of England" in many a crowded city, as known to a limited class, are a curse to all who live in them, and a menace to the rest of the population. It is Society's business—which it cannot escape—to see that the welter of filth and vice in which the criminal and mentally deficient clique is bred, generation after generation, shall be removed, and its perpetuation be made impossible. This is the modern Augean stable that awaits its cleansing by Society. Just as in the past the plague and fevers without end came through filth, so today whatever foul disease gets hold of the community is carried from city to city, and spread chiefly by one type of person. Often the tramp is the bearer of disease, and he transmits it through the people of the quarters he frequents. No cost is too great for the conquest of the tradition of dirt and disease, which remains from the ages of dirt and disease, and no claim for the liberty to breed and spread contagion should be allowed. Even if, for a time, segregation of the contaminated who, alas! know nothing better than the state to which they were born were resorted to, the cost would be small in comparison with the benefits that would follow in public safety, and finally in public economy.

Accustoming the Public Mind to the Duties it Must Undertake

The change may come quickly; for remember that everything done compulsorily for the preservation of public health in ordinary times has been done during the last fifty years, and public opinion approves of what has been done, even though it resisted initiation on the ground of expense. More will be done soon, accustoming the public mind to public action and responsibility, through the support of hospitals that can no longer exist on a voluntary basis and through a national treatment of the problem of allowing the feeble-minded to perpetuate their deplorable type.

THE HANDICAP ON FAMILIES

The Need for the Realisation of the Claims of the Race upon the Individual Through Marriage

PUBLIC HELP FOR WORTHY PARENTHOOD

In discussing Positive Eugenics, we have now dealt with first principles. We are going to proceed by way of marriage, which we desire to be the expression of natural, personal love, and we abandon all ideas of compulsion. Our delay in discussing this subject on practical lines was due to the hope of guidance from the Eugenics Congress, but Positive Eugenics was scarcely discussed on that occasion. We are well aware of the difficulties in front of us. Two distinct issues have to be dealt with. We commonly speak of them as if they were one, but we should know better. In the first place, we want to see worthy young people of both sexes marrying, and doing so not too late in life. If marriage is much delayed on their part, posterity will lose some of their children, perhaps those of their best parental years; and the man who delays his marriage runs many risks, some of which may be terribly relevant to eugenics.

Here is a problem in itself, against the solution of which the whole trend of civilisation seems to conspire, for the marriage age tends persistently to rise, in both sexes; there is in our own country a great preponderance of women, and in our Colonies a great preponderance of men, both conditions being dangerous and inimical to eugenics; and there is an increasing tendency to revolt against the present conditions of marriage. But suppose that we have somehow conquered these difficuties, and the people we desire to do so are marrying each other, at suitable ages. This is not eugenics, and does not become so until these people become parents. But that is a new question, and a quite distinct one.

The most important and far-reaching fact of modern civilisation is the absolute control over parenthood which mankind is acquiring. Nothing can arrest for long the spread of knowledge of any order. Such knowledge, in this case, has been desired by mankind for ages. Failing it, infants who were not wanted have been slaughtered by millions, and especially female infants. Where the state of the law or religion or public opinion has interfered with infanticide, young lives have been arrested antenatally, as indeed they now are, even in our own country, in all classes of society. Finally, mankind has acquired such knowledge as may interfere with the inception of the young life at all.

Hosts of thoughtful people deplore the fact, but, whether they do so wisely or not, the fact stands. To the present writer this form of knowledge seems much like any other. "Knowledge is power," and, like all other forms of power, may be used for good or for evil. Dynamite may entomb or untomb. This piece of recently acquired knowledge may often be used wrongly, and for the injury and hampering of those who employ it. So may the power to read or to write or to reckon. On the other hand, we may argue that, whether by means of self-control or otherwise, it is now established that parenthood may be made a completely responsible act, foreseen, intended, deliberately willed. This fact seems to serve the eugenic ideal that every child which comes into the world shall be willed, desired, and loved in anticipation. No form of knowledge can be wholly evil, surely, which makes parenthood more deliberate and more responsible. It is now within the power of man as never before, and with more power comes more responsibility. The time is not far distant when we shall be entitled to say to every father, as indeed we might almost say now, that he deliberately chose to become a father, and that hereafter he must be held responsible in every way for his tremendous act.

But the ever-widening dissemination of these forms of knowledge and power constitutes a most formidable problem for the Eugenist. If this were a century ago, in the days of Malthus, then the Eugenist could simply proceed with his attempt to influence favourably the incidence of marriage, as Malthus did, confident that marriage meant a natural and adequate sequel of the children whom the Eugenist desires.

The Clash Between Personal Ambition and Family Growth

We still talk and write in this fashion. We discuss all sorts of systems for the encouragement of worthy young people. We recognise a eugenic agent in the scholarship system, or in the examination system, or what not, because thus "able" young people are favoured. Being thus favoured with posts and emoluments, they will marry and produce children who will inherit their valuable qualities, we assume. And we are quite right, until we reach the crucial last clause. It is, in fact, possible to prepare statistical tables which show that the systems whereby we tend to discover and favour "able" young people are also systems whereby we succeed in obtaining from them fewer children than they would otherwise have had; or, at any rate, certainly fewer than those produced in the class from which we recruit these favoured individuals. You plant ambition in the youth's mind, and he becomes less ready to give hostages to fortune. He marries, perhaps, but he makes his own decision as to how many children he shall have; and, as he finds that a large family would seriously handicap him, he acts accordingly. We all exhort other people to keep up the birth-rate, and meanwhile it falls.

The Complex Considerations that Influence the Expansion of Family Life

There is no putting back the clock. We are in the era where individuals can and will determine these things for themselves. These are matters of racial and national concern, but they also happen to be the most private and personal things in life, and will remain so. The factors which the Eugenist must try, if possible, to influence for his end are numerous and varied. All statements and proposals which assume that they are only one or two may be written down at once as useless, because they are false. Both sexes have to be considered. With the possible fathers, the economic factor is dominant. With the possible mothers, there is is the economic factor, but there is also the personal factor of desire to avoid pain, inconvenience, loss of looks, and so forth. Nothing can be more ignorant or unjust than to call all voluntary control of the birth-rate "selfish"; it may often be the expression of an unselfish desire to do better for fewer children than less well for more.

In many instances, the people who come under these sweeping eugenic condemnations are refraining from parenthood on eugenic grounds, because of some defect or taint in themselves, of which they are aware, though similar people, in past generations, would have had neither the knowledge nor the will nor the interest to refrain from becoming parents on such grounds. Let us therefore proceed with some care and hesitancy. Our best course will surely be to disentangle the factors of the problem, and deal with them separately.

For convenience, we may leave certain questions which may be earlier in logic, and are no doubt deeper, and may proceed to the consideration of one large question, which cannot be gainsaid or escaped. This is the economics of parenthood, a matter which is now engaging the anxious attention of legislatures in many parts of the world, and which has, indeed, lately been the subject of definite and practical legislation.

The Vicious Handicap of Parents Against Those who are not Parents

Let not the reader for a moment suppose that in treating this matter first we regard other matters as negligible. We are well aware that the initial question is as to the persons, the personalities, and the genetic possibilities of the parents in question. But the fact remains that, in the modern world with parenthood become or becoming a matter of deliberate volition, the economic question comes into everything. If the economics of parenthood could be favourably modified, we should find the initial and primary facts of marriage undergoing a favourable modification too, especially as regards the present tendency, on the part of many responsible and worthy persons, to delay the marriage age far beyond what we should desire.

The fact that parents are now handicapped as against non-parents in the struggle for life needs no insistence. Probably no one will be found to question that this handicapping is vicious in principle and in result. It is observed everywhere and hence various proposals and practices may be observed. They tend at present to be crude and casual, but they are very significant as showing the direction which legislation is being forced to take. The

general principle, of course, is not novel. Our married soldiers have advantages in proportion to the number of their children. Under the provisions of a recent Budget, a father whose income is less than £500 a year is allowed a remission of income-tax equal to 7s. 6d. for each child. A new experiment of this order was inaugurated in France during the present year, it being possible now to rent flats in which the birth of a child frees the tenant from the payment of rent for the quarter following the happy event. This expedient for encouraging larger families is being tried at Vincennes, an eastern suburb of Paris, where the profit remaining after the cost of building certain flats, and payment of working expenses, will go to the maternal canteen, where mothers nursing babies will be supplied with lunch and dinner free of charge. The flats include baths and washhouses, a library, and a dispensary for new-born children.

The following are the proposals of M. Jacques Bertillon, which are to be laid before the new French Commission on the birth-rate. "Frenchmen must be taught to regard a child as a burden which its father supports for the benefit of the whole community. But in order that a family should pay what it owes to the State, it should consist of at least three children—two to fill the places of the parents when they die, the third to fill the gaps caused by those who die before attaining adult age.

Proposals and Arrangements for Reduced Taxation where Families are Large

"In order to promote this end, M. Bertillon proposes a reduction of taxation upon fathers of three or more than three living children, in proportion to the number of living offspring—a system already adopted in Prussia, Saxony, Servia, Norway, Sweden, and parts of Switzerland. The laws of succession should be modified, and formalities of marriage simplified. Mothers of large families should be assisted in various ways, and especial provision should be made for widows left with children. Finally, M. Bertillon suggests that, among the humbler class of public servants, those candidates for employment by the State who have children should be considered as eligible in proportion to the size of their families."

Such straws as these show which way the wind blows. We shall do well to consider more carefully the kind of help for parents which is desirable. Simple bonuses for children are often suggested, but such a proposal is surely too crude. It savours too much of a species of compensation, and it may entirely fail of its purpose. The problem before us is not merely that promising children shall be born, but that they shall be kept alive. Nothing in the nature of a bribe is what will serve our purpose. We shall have to offer parents certain substantial advantages, but they must be essentially for the children's advantage, and the parents' aid thereto.

We want to see children produced primarily for the love of children: and we must be cautious in listening to people who are for ever speaking about "breeding for ability," and at the same time telling us that eugenics is part of our religion.

The Racial Call for Tender Instinct rather than for Mere Ability

We want other things besides ability—a non-moral form of power which, like sunlight or dynamite or printing, may be turned to vital or to mortal ends. There is plenty of ability in the world which, used as it is, the world would be better without. We want the parental instinct and the "tender emotion" which is its correlate in the affective (which is also the effective) realm of our nature. We therefore want children to be born to those who have the love of children. That is the first if, indeed, it be not also the last essential. On the one hand, we must on no account interfere with or hamper the production of children by such people: and on the other hand, we must consider whether it is right to attempt methods of bribery for the production of children on the part of people who do not desire children for their own sake.

We must give adequate help to parents, but we must hold hard by certain principles meanwhile. These are that the help is not to be a bribe; that it is to be specific, definitely reaching the point towards which it is aimed, and not, for instance, slipping into the public-house till by mistake; and that it is to be steady and continuous, like the child's needs.

Legislation that may have Reduced Child-Life by Reducing its Earning Power

The first fact we discover is that, at present, we handicap parents in some unexpected ways. Free education, as against compulsory education which has to be paid for, is certainly a form of parental help. But education, however free, which involves forbidding the parents to profit, as they would otherwise have done, by their children's premature earnings is a menace to parents who fear the strain of long provision and the too long delay of any returns. Factory legislation, and the

MATERNAL LOVE—THE FOUNTAIN-HEAD OF ALL HUMAN KINDNESS & OF MORALS

THE HEALTHY, STRONG TYPE OF MOTHER RATHER THAN THE MOTHER OF ABILITY, IS WELL EXPRESSED IN THIS PAINTING BY ROBERT KEMM

whole body of enactments which protect childhood, are clearly right from the point of view of nurture, but they are by no means eugenic in the long run if, by handicapping parenthood, they result in a lowering of the birth-rate among the very best, most provident, and most responsible members of the working class.

There are those who believe that the great fall of the birth-rate in many of our large industrial cities actually depends in some measure upon legislation of this class, and attempts have been made, without much success, to connect sudden falls in the birth-rate with the incidence of new factory laws. However that may be, there is no doubt that, in the recent past and among certain sections of the community, children have been looked upon as an investment for old age, in virtue of their early earning power; and arguments have been directed against factory legislation on the ground that it tends thus to lower the birth-rate. But whether any wise and kind person can really want children to be produced for such reasons, and for such a fate, is another question.

Maternity Benefits and the Assistance of Worthy Parenthood by the State

We have already referred here to the maternity provisions of the Insurance Act. In the Australian Commonwealth, it appears, the provision for each birth is to be no less than five pounds. The German provision for maternity is much more generous than ours. But necessary and admirable though such provisions be, they are purely temporary, and do not at all solve the problem of the economics of parenthood. The question which is coming close upon us in this country, and is already engaging the most thoughtful men in France, is to determine how far we shall have to grant further parental help in proportion as our demands for the care and nurture of childhood become more stringent, and especially in so far as they are extended, as they must be, to the earlier years of adolescence.

It was the last admirable suggestion of Sir Francis Galton that we should seek to turn the stream of charity to the service and assistance of worthy parents and worthy children instead of allowing much of it, as at present, to fertilise the growth of worthless or even noxious weeds. This excellent proposal has to meet the opposition of two mutually opposed classes of extremists. There are those thorough-going advocates of State Socialism, who object to all forms of charity or voluntary agency, and who desire the State to undertake all provision for everybody. Then there are the stern Individualists, survivors from half a century ago, who object to any form of charity, as weakening self-respect and independence and favouring the multiplication of the unfit. Failing any prospect of the mutual destruction of these parties, to the incalculable gain of the public at large, Eugenists must everywhere seek to discharge their duty of educating the benevolent, so that the great stream of charity which flows unceasingly in this, and doubtless in other, countries may be directed and inspired by the eugenic idea.

The Universities the Only Institutions where the Young are Fully Nurtured

Charity, however, will certainly not be the ultimate solution of this problem. The proper nurture of the young will in the future be more expensive than ever it has been. It will require more expert direction, and much longer continuance of that direction. At present the nurture of the young, in the fullest sense of the word, is completely undertaken only in the case of the very few who profit, more or less, by the endowments of our Universities and great public schools. It is not generally recognised that the State, the existing generation, supports these institutions, just like those where the children of the poor are educated, but the fact is evident to any student of political economy. It helps to make clear the fact that the nurture of the young, on the ever-rising standard of our times, is more than a matter which individual parents as a whole can be expected to undertake. If we do entertain such expectations, the parents who would have been simply decline to undertake the burden.

The Increasing Cost of Nurture an Economic Handicap of Parenthood

The fact is clear that the rising standard of nurture for the young constantly increases the economic handicap of the parent as against the non-parent. We have seen how this tends to work out in the case of the artisan class, and all classes in which the former custom was for the parents to be early supported by their children, at ages when we now expect them to be expensively maintained and educated for many years to come.

The economic handicap of parenthood shows itself in many ways which nothing but an educated public opinion can rectify. Just as these words are written we hear

of a typical case, where the Kingston-on-Thames Board of Guardians are advertising for a master and matron of irreproachable character *without encumbrances.* This word "encumbrances" is actually the recognised term for children in this connection. All over the country the same conditions exist. Not only does the father find his income less adequate for his needs, which are also national needs, but he actually finds it more difficult to earn an income at all because he is a father.

The "Reversed Selection" which Publicly Chooses Married People Without Children

Thus, at the present time, we have a widespread system of "reversed selection," whereby in many ways favour and opportunity are shown to those who have no children, as against those who have. The highest personal qualifications of every kind are desired and sought, just such qualifications as are desirable in parents, but parenthood is forbidden. In a properly instructed state of the public mind it would be quite impossible for any public body to issue such advertisements, whatever action individuals may take. In any case, it is surely a most improper and disgraceful thing to think or speak of children as "encumbrances," as the Kingston Board of Guardians does; and modern civilisation has little to boast of, compared with the ideas of ancient Jewry or of contemporary China, when children even, if you will, male children—can be so described. One of the obvious duties of Eugenists is persistently to protest, by letters to the papers, by action upon public bodies and elsewhere, against the morbid state of opinion which makes such advertisements possible. If it is improper and even illegal to dispense information regarding the prevention of parenthood, surely it is no less improper to speak of children as encumbrances, which anyone may therefore reasonably seek to avoid.

The Difficult Problem of the Married Woman Teacher

Much more difficult is the vexed question of married women teachers in our schools. It is so difficult that, after much reading of what has been written on both sides, we forbear the making of any decision of our own. This is a conspicuous instance of those questions where true and powerful arguments can be advanced on both sides. It seems a great shame that a woman should lose her situation because she marries; and the marriage, as such, seems no sufficient reason. The tendency in this direction may be dysgenic, another instance of "reversed selection," by discouraging the marriage of many worthy individuals. On the other hand, the right place for a mother is at home, and the right children for her to look after are her own; nor do we want to encourage paternal idleness or irresponsibility. The case is so complicated that the right course cannot possibly be maintained in all cases by means of a hard and fast rule. The tendency of authorities, however, is to make such rules, not distinguishing between the married woman who is a mother and the married woman who is not.

One other point alone need be made in this difficult connection. In this country we suffer the wholly vicious and abnormal condition of having a great excess of adult women in the population. The problem for them and for the nation, under a condition of monogamy, is practically insoluble. It should not arise; and the day will come when the nation deliberately corrects this wholly artificial and unnecessary disparity.

Some Parental Advantages of a Small Over a Large Family

Meanwhile the best we can do is to find employment psychologically appropriate for the women who cannot marry, and such employment must obviously be some aspect of the nurture and education of children which is part of the natural business of women. Therefore, it looks as if the mothers should be in the homes, and the unmarried women in the schools. Yet, when the arguments on the two sides are weighed one finds it almost impossible to give the judgment to either.

In conversation with the present writer, Mr. A. J. Balfour remarked that "Probably you can get as much pleasure out of three children as out of six." The parent can indeed satisfy the parental instinct and the tender emotion as well upon three children as upon six, if not a great deal better. If this be granted, and if we remember that the deliberate control of parenthood is rapidly extending through all classes and sections of society except the actually defective, we shall see that in the near future, children being wanted, the State will have to pay for them. This sounds very crude, and need not be stated so crudely. The ideal would seem to be that it shall "pay" no one to become a parent, and that, on the other hand, no one shall be cruelly handicapped in the struggle for existence because he becomes a parent.

We complain of the fall in the birth rate now, but what should we say if the birth-

rate were now what it will in all probability be a quarter of a century hence? The fall in the birth-rate has, in fact, only just begun. No really effective measures can be taken which do not directly involve the protection of parenthood, the greater care of those who are born and of those who bear them—this being, in all reason, the first charge upon the resources of any community which wishes to endure—and the complete relief of parenthood from the economic handicap to which it is at present subjected. Mere objurgation about the falling birth-rate, mostly by bachelors, will avail nothing.

The Parental Handicap a Substantial Reason why Desirable People have no Children

Of course, it is with what we have called eugenic marriage that positive eugenics must begin. Only we have here kept this question distinct, and are purposely treating it second, because it is in fact distinct, and because Eugenists have too long assumed that it is the only question. In point of fact, the desirable people marry, and that is well, but they produce no children. Then we turn round upon them and abuse them. We should more honestly recognise the existence of the parental handicap which has here been insisted upon, and which some countries, as we have seen, do already recognise, and try to reduce by means of differential taxation. But if we recognise the double character of the problem before positive eugenics, let us proceed to look at the factors by which we may further the initial stage, to which we have given the name of eugenic marriage.

Plainly we must begin with what we have already discussed as education for parenthood. Then we propose to trust human nature for the rest. Biologists become increasingly doubtful about the efficacy, or even the existence on any large scale, of what Darwin called "sexual selection" in the lower animals.

The Natural Selection that is at Work where Women Predominate

But there can be no question as to the existence of "sexual selection," in a humanised form, among ourselves. In any sub-human species, where no female goes unmated, it is difficult to find much scope for the effective action of sexual selection.

Among ourselves, with something like a million and a fifth more adult women than men, and therefore with a very large number of women who do not become mothers, it is evident that some kind of selection must be at work. Some women are married and some are not; and there are factors at work which determine the category to which any given woman shall belong. On the other side, a certain number of men who desire to marry remain unselected, though women do not have a fair chance, under present conditions, of discharging their supreme function, which is that of choosing the fathers of the future.

The propositions are here laid down that the human form of "sexual selection," in a properly nurtured community of young people, would work eugenically; that all other factors of selection whatsoever are dysgenic; and that our simple duty is to try to reduce the disturbing, vicious, unnatural operation of those factors. As far as the choice of women by men is concerned, perhaps things are not so far wrong. In the present state of civilisation, a free choice within a considerable range is open to most men, in virtue of their economic advantage, and. in our own country, in virtue of their relative fewness. That their choice is, on the whole, eugenic, fortunately for the race, no reasonable person will dispute. Men do marry for money, or for social advantage, or for other reasons, of course, but the great majority of men marry for what is, at least in its foundations, a sexual, physical attraction. In the normal man the factors of this attraction are eugenic.

A Racial Reason for the Popularity of the Corset

Some years ago Dr. Havelock Ellis pointed out the enduring reason for the popularity of the corset, which, as Dr. Arthur Evans's researches in Crete have shown, flourished during the civilisation of three thousand years ago, and advertisements of which fill our papers today. The essential character of the corset is that it applies such compression as shall accentuate, by contrast, the specific features of a woman's form, those features which are associated with, and necessary for, maternity. Totally without forethought or knowledge, totally unaware of the explanation of his own preferences, the normal man is nevertheless eugenic in instinct, sometimes intensely so. He is attracted by the woman whose form and features, whose vitality, sympathy, and tenderness, indicate individual health and fitness, physical and mental, for the tremendous function of child-bearing.

No doubt the tendency to make superficial judgments is a general weakness of mankind, and men are often unduly influenced by characteristics which are not sufficiently valuable. The extraordinary

and inimitable attraction of beauty, which "draws us by a single hair," often seems and is absurd and disproportionate. Very often the beauty is of the kind which is only skin-deep, and the moral and mental characters of the possessor may be little worth having. But, on the other hand, physical beauty --at any rate of the types which most men admire—is very closely associated with health, a characteristic which we cannot do without. Fine qualities of mind and character tend, also, to show themselves in the face, and thus tend to be chosen in the guise of those forms of beauty which are more than skin-deep.

One of the tragedies of modern life, however, is the existence of a certain number of finely contrived, fastidious, sensitive women, not easily satisfied, who shrink from marriage under its present conditions. In the past, when women were mostly brought up in entire ignorance, and were then married without in the least knowing what life and marriage meant, things were different. It does not seem likely that that time can ever return. Today many women of the finest type remain unmarried, and the race loses the valuable qualities which they might have transmitted, because they are too well aware of the conditions of an institution which is much more convenient, at present, for men than for women.

The Wider Range of Man's Selection in Marriage Compared with Woman's

But when we look at the other half of "sexual selection" under human conditions, namely, the choice of men by women, we see at once that eugenics must make many large and serious demands before its claims can be satisfied. Under modern conditions any man who chooses may marry and become a father. There are hundreds of thousands of men in England today who are not fit to become fathers. Under perfect conditions of sexual selection the race would be protected from their children, for no woman would look at them. But under the conditions which actually obtain they can buy what their natural qualities cannot earn. If there be any profound and potent reason for which woman was endowed with her sensibilities, her delicacy, her intuition, her strong likes and dislikes, it is that these qualities may be exercised in her great task of distinguishing worth from unworth, choosing those whom she prefers to be the fathers of the future, and rejecting those who do not come up to her standard.

The power of money goes very far indeed to make this of none effect. Money, position, everything that it means to a woman to be married, apart from the vital things—all these act so that masculine unworth may be perpetuated, though the profoundest instincts of woman would reject it. If there be anything in Darwin's theory of sexual selection, the choice of their mates by the females of many animal species has been potent in maintaining the quality of those species. The pity is that abnormal and artificial conditions should vitiate what would be the undoubted action of the same factor in the highest species of all.

Marriage Reform Needed Upon Strictly Biological Lines

So we must lay down the principle that when we think or speak of the reformation of the laws and conditions of marriage, we must necessarily mean such reformation of that great institution as shall be eugenic. In such discussion the Eugenist means that public opinion, and legislation, too, shall operate against the making of such criminal marriages as society daily exemplifies, blessed by Church and State, but accursed by Nature. He means that the first consideration in the choice of men by women and of women by men shall be the natural value, the biological *status*, of the individual in question; what he or she is, not what he or she has.

As for divorce, one or two facts are clear. That a woman should have motherhood forced upon her by a chronic inebriate, he being her "lawful husband," is so evidently wrong that it cannot possibly be right. Eugenic marriages may be "made in heaven," but there are evidently dysgenic marriages which were made elsewhere. Certain modifications of the laws of divorce would evidently serve the cause of both positive and negative eugenics.

The Undefined State of Positive Eugenics, and the Need for More Knowledge

With these considerations we must conclude our study of positive eugenics. There are other difficulties, which perhaps we scarcely yet perceive. We lightly talk about the marriage of worthy persons, but we know little yet about human genetics, and it may well be that, even within the group of those whom we "pass" as worthy, there are only certain parental combinations which would prove to be of eugenic value. We need far more knowledge. Meanwhile, we may pass from positive or Galtonian—eugenics to other matters of no less importance, where both our knowledge and our duty are clear.

WANDERING FIRE-MISTS

The Vast Journeyings of the Comets Through Outermost Emptiness, and Their Recall by Sun and Planet

VISITORS TOO SWIFT & FINE TO BE KNOWN

THE majestic spectacle of the starry sky is too generally disregarded, but there are rare occasions when everyone is gazing heavenward. A golden shower of shooting stars attracts attention; an eclipse of the moon much more; but a notable comet has in all ages been the chief wonder of the night. Everyone remembers the marvellous comet which appeared recently, and the interest it excited. Discovered at Johannesburg, on January 16, 1910, it was eagerly searched for in Britain, and was seen three days later by the astronomers of Cambridge Observatory. It was travelling at such a speed that in the interval of three days it had moved from a position four and a half degrees east of the sun to a position westward from the sun. It was then clearly visible to the unaided eye, shortly after sunset. It grew daily brighter and more impressive, and revealed a tail of enormous length, stretching upward from the horizon and slightly curved. The nucleus, a central point of condensed brightness in the comet's head, was as large as the planet Venus and as bright as Mars. This nucleus was of a dusky red colour, the surrounding nebulous mass of the head being of a fainter red, and the tail yellow. The comet had two tails; for, besides the main tail, which was a bright, fan-shaped jet of light projected toward the zenith, there was also a fainter and straighter secondary tail, short and bushy, and inclined about twenty degrees to the axis of the former. The main tail, which branched into two sharply curved streamers of equal splendour, was found by measurement to have a length, on January 29, of sixty-two million miles, and extended, at its greatest length, for a distance of fifty degrees across the sky. This was one of the few bright daylight comets that have visited us since the beginning of the nineteenth century. Those of 1843, 1847, 1853, 1861, and 1882 are also famous in astronomical annals.

The magnificent comet of 1910 appeared at a time when the attention of many observers was concentrated on the movements of Halley's comet, which revisits our skies periodically, and had already been discovered on this visit as a faint nebulous body on a photograph in September, 1909, though it did not become visible to the unaided eye until early in February, 1910. By a strange coincidence, a similar appearance of some other visitant has marked several former returns of Halley's comet. This, indeed, has happened so frequently as to make the tracing of Halley's comet in old records a difficult and complicated matter. Yet the history of the visits of Halley's comet has been well made out, and has exceptional interest, because it gave rise to the discovery of the true nature of cometary movements.

Edmund Halley, born in London, carried out much important astronomical work in the island of St. Helena, and was later Professor of Astronomy in Oxford, and finally Astronomer-Royal at Greenwich. On the appearance, in 1682, of the comet known by his name, Halley was the first to put forward the theory of its periodic return. Up to that time it had been supposed that every visit of a comet showed a separate body, which had never before appeared in our sky and was destined never to return. But Halley observed that the orbit of this comet of 1682 coincided very nearly with the orbits of the comets of 1607 and 1531, and found also that there were records of great comets having appeared in 1456, in 1301, in 1145, and in 1066. He recognised that although the intervals of time were not exactly equal in all cases, the differences were not greater than might be accounted for by perturbations due to the influence of planets.

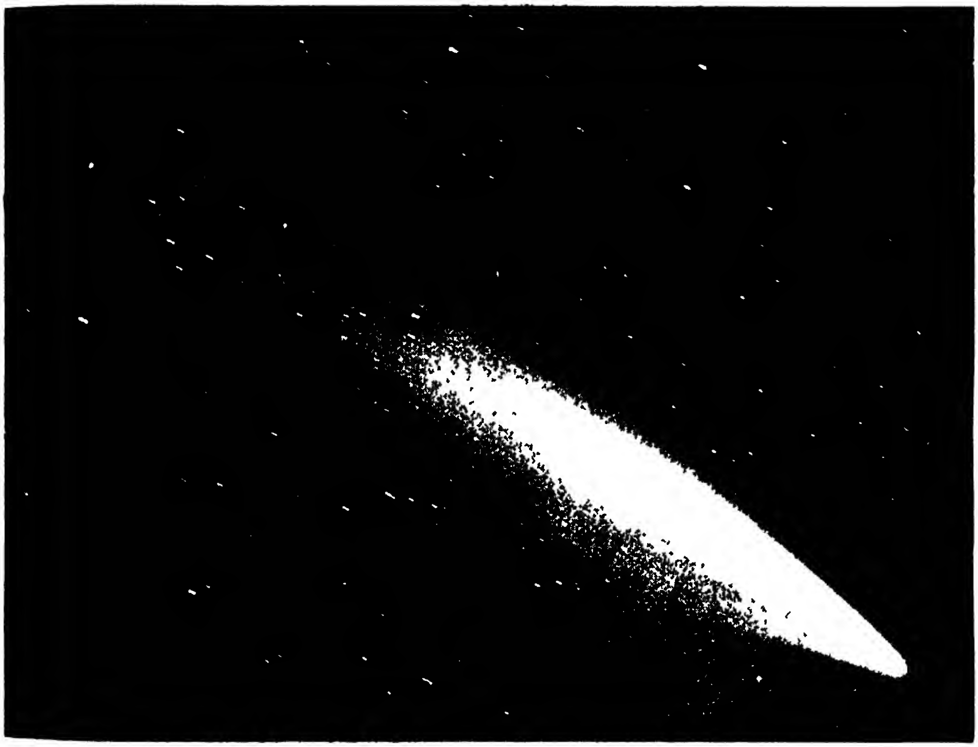
A GREAT COMET THAT TAKES MORE THAN THREE THOUSAND YEARS TO COME ROUND AGAIN

[illegible] the passage of a comet that witnesses the ruins of empires which were in all their glory when [illegible]
1811 Its former appearance was at the time of the Trojan war Assyria Greece Rome Carthage what are they?' Its next arrival will be in the year 4876

Starting from these records, Halley ventured on the first prediction ever made with regard to a comet. He came to the conclusion that all these apparitions were the reappearance of the same comet at intervals of seventy-five or seventy-six years, and foretold that if his deductions were correct the next return might be looked for in the early months of 1759. Before that time arrived, mathematical calculations of a much more precise nature had become possible with regard to the probable influence of planets, and Clairaut was able to predict what effect Jupiter would have in retarding the arrival of the comet. He fixed on April 13 as the date when the comet would pass nearest to the sun, but was careful to say that the possible action of other more distant planets, as yet unknown to astronomy, might retard or hasten it by a month. This was before the discovery of the two outer planets, Uranus and Neptune.

The comet actually came to perihelion—that is to say, its position nearest to the sun—on March 13, 1759, thus establishing its identity with the visitants recorded in history, and proving the truth of Halley's theory of periodic comets. We know therefore that the comet which was hailed as a gorgeous omen of victory for William the Conqueror, and is so depicted on the Bayeux tapestry, was Halley's comet itself, which last appeared in 1910.

Since Halley's brilliant discovery, more than a dozen comets have been actually observed to return in periodic courses, two other comets besides his own having periods of between seventy and eighty years. The periodic nature of the orbits of many other comets has been demonstrated, though their return has not been actually witnessed. But of all periodic comets, Halley's remains by far the brightest and most important.



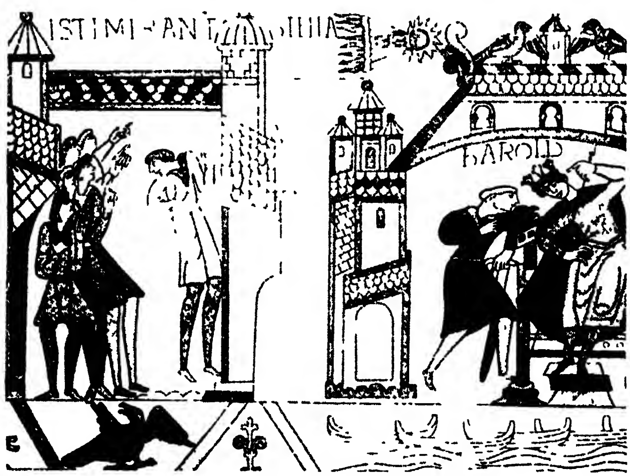
A PHOTOGRAPH OF THE COMET OF JANUARY, 1910, TAKEN AT THE LOWELL OBSERVATORY

The importance of this discovery will be understood when we realise that comets cannot be identified except by means of their orbits. There is nothing constant in a comet's appearance. The only feature of these bodies we have to depend upon is their movement, and even that is difficult to calculate, because it is liable to all kinds of perturbations from the influence of the planets. These disturbances may be very violent, and may even result in the entire dissolution of the comet itself.

The appearance of an individual comet is liable to extreme variations. It may appear at one time with a tail and at another time without any; it may be now

very bright and again much fainter; the nucleus may be definite and brilliant like a star, or there may be no clearly defined nucleus at all. Indeed, all these and other changes may be observed in a comet during a single visit, at different stages of its progress. Its appearance, therefore, is no clue to a comet's identity; to establish this there remains only the determination of its orbit—that is to say, the path of its journey through space.

Before the discovery which was confirmed by the predicted return of Halley's comet, very various ideas had obtained with regard to the movements of comets. Aristotle, and many who followed him, regarded them merely as exhalations from the earth, which became ignited in the upper atmosphere. Some of the ancients looked upon them as living creatures, moving with self-directed motions; and from the earliest times down to a fairly recent date they were regarded as omens of disaster. It was not until the seventeenth century that the suggestion was made that certain comets moved in parabolas, but Halley was the first to conclude that there are comets which travel, like the planets, in elliptical orbits, and consequently return after regular intervals. Since then it has been proved that all comets move either in parabolic or in elliptical orbits, and therefore obey the universal law of gravitation.



HALLEY'S COMET AS DEPICTED ON THE BAYEUX TAPESTRY

Comets thus fall naturally into two classes: those which return, and are known as periodic comets, and those which do not return, the former moving in an ellipse, which is a closed curve, and the latter moving in a parabola, which is an open curve, of which the ends meet only at infinity. But this does not imply that all the comets that have been observed can be classified as having parabolic or elliptical orbits. Of those determined so far, about two hundred have definitely parabolic orbits; fifty or more follow orbits that are very clear ellipses of oval form; and about twenty more are apparently elliptical, but with periods so long that their character has not been established with certainty.

Inasmuch as over seven hundred comets have been catalogued, it is clear that the orbits of a large number have not been clearly determined. Moreover, the orbits of comets are at any time liable to be very considerably changed by the influence of any planet which they may approach; for the mass of a comet is so extremely small—that is to say, its body is so incredibly light—that the vicinity of a planet is sufficient to alter its orbit to the extent of a period of many years. By the same influence, a comet's orbit may be changed from a parabola to an ellipse, or from an ellipse to a parabola.

A comet is visible only through an extremely small section of its orbit—namely when it is at that end of its ellipse or parabola which turns round the sun. It is therefore difficult to obtain, with accuracy, the measurements which are necessary for the determination of the orbit; and this difficulty is greatly increased by the size and nebulous form of a comet, which presents no definite point for measurement except when the nucleus is very sharp and bright.

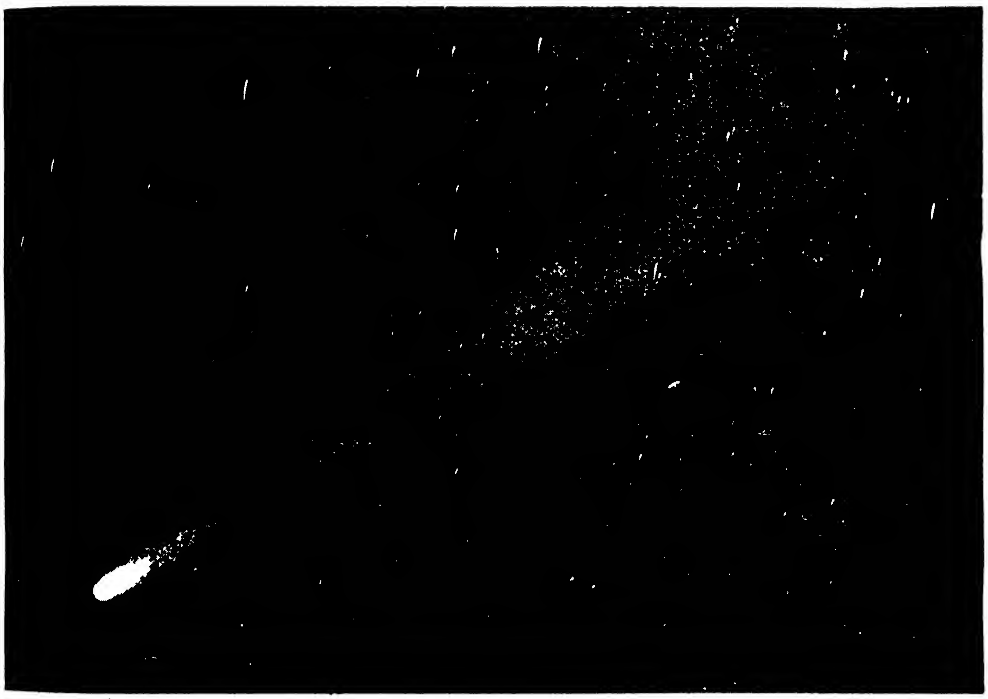
Since the majority of known comets apparently move in parabolas, and consequently visit our sun once and depart never to return, they cannot be regarded as belonging to the solar system, but are rather visitors from the spaces beyond its confines. Those moving in ellipses, on the contrary, are of course part of the system, and revolve regularly round the sun. But though they now belong to our solar system it seems likely that they, too, like the parabolic comets, came to us as visitors from space, but have been captured by one or other of the planets.

This view is supported by the fact that many of them are in some way connected

with individual planets. Thus, all the short-period comets, which return to us at intervals of from three to eight years, pass close to Jupiter's orbit at some point in their path, and appear to have been captured by his powerful influence. These, numbering sixteen, are known as Jupiter's family of comets. Saturn has a similar family of two comets, one of them with a period of thirteen years. Uranus has three comets. Neptune has six, including the three known comets with periods of from seventy to eighty years, among which is Halley's famous comet.

It is believed that a comet entering the solar system in a parabolic orbit and passing near a planet would have its motion either accelerated or retarded by the influence of the planet. If it were accelerated, the comet would pass out into space again in a still wider curve—namely, a hyperbola; but if it were retarded its orbit would become elliptical, so that it would return again to the same position at regular intervals. Successive encounters with the planet might in time result in reducing the comet's orbit to the small size of those of the short-period comets, though this result would take an enormously long time to come about; and the theory requires a very large original number of comets, because each original capture would be liable at every encounter to have its velocity accelerated and its orbit rendered hyperbolic, so that it would disappear again into outer space.

There are six or more groups of comets of a peculiar and interesting kind. In each of these groups the comets pursue apparently the same path, but follow one another much too closely to be, by any possibility, merely successive appearances of the same comet. It is therefore suggested that the several comets of any such group have a common origin, and that at some remote period they formed, or were parts of, a single body. Some of the famous comets of the last century belong to one group of that kind, namely, the comets of 1882, 1880, and 1843, and to the same group belongs also the comet of 1668. Now, the orbit of the 1882 comet was computed to have a period of from six hundred to nine hundred years, so that none of the other comets of this group, though pursuing the same orbit, can be regarded as former appearances of this comet of 1882. As we shall presently see, considerations with regard to the physical constitution of comets. and various changes which have been observed in them, tend to support the view that several comets moving at intervals along the same path may have originated by



HALLEY'S COMET, PHOTOGRAPHED IN MAY, 1910, AT YERKES OBSERVATORY, U.S.A.

the disruption of a single comet. Comets move either direct—that is to say, in the direction of the planets—or retrograde; and about as many travel in the one direction as in the other. But, with the exceptions of Halley's comet and the comet associated with the Leonid shooting stars, all which have elliptical orbits with periods of less than one hundred years have direct and not retrograde movement.

A comet—so called from a Greek word meaning long-haired—consists of three parts more or less distinctly marked. These are the head, the nucleus, and the tail. The head, or coma, is a faintly luminous nebulous mass, and is the first part to become visible as the comet approaches the sun. It has somewhat the appearance of a much blurred star. The dimensions of the coma are often enormous. Even comets that can only be perceived through a telescope are seldom less than forty thousand miles in diameter, and are often much more, while some of the famous comets, visible to the unaided eye, have had heads larger than the sun himself. For instance, the head of the comet of 1811 showed at one time a diameter of twelve hundred thousand miles, being nearly half as large again as the diameter of the sun. On approaching the sun the head of a comet is always seen to contract, but this may be merely an optical change, due to the effect of the brightness of the sun in rendering invisible some part of the luminous matter composing the comet. One would expect the body to expand rather than to contract under the influence of the sun's heat.

The nucleus, as has already been said, is a mass of condensed brightness within the head. It is not always present, or rather, it is not always visible. It varies considerably in size, the largest on record having been that of an 1845 comet, whose nucleus measured eight thousand miles in diameter. In some cases the diameter is as small as one hundred miles. Frequent changes are observed in the nucleus as the comet progresses in its swing round the sun. It becomes more definite and brighter as it approaches, and shows signs of various forms of activity. Often it throws out jets of light on the side toward the sun, or gives off concentric envelopes of light, which widen out like circles made in water by a falling stone, to lose themselves in the general nebulosity of the head. Occasionally the nucleus has even been known to split up into several parts. This was notably the case in the comet of 1882, whose nucleus divided into four or five portions, presenting the appearance of beads strung together on a narrow, connecting thread of brightness.

The tail of a comet is at once the most striking and the most puzzling part of its anatomy, and many voluminous theories have been put forward concerning it. The tail is often of enormous extent, sweeping over the heavens generally in a beautiful, plume-like curve of widening light. Those

HOW OUR EARTH PASSED THROUGH THE TAIL OF HALLEY'S COMET IN 1910

The orbits crossed at A, so that the earth was only immersed in the extremely attenuated tail of the comet.

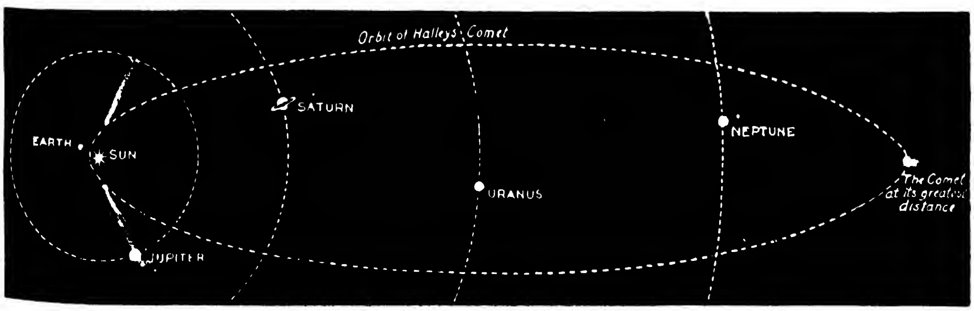
of several comets, including among recent examples the comet of 1882, have been found to exceed one hundred million miles in length, and at the extremity to be something like ten million miles in breadth. These are perhaps exceptional, but it is by no means unusual for a tail to attain the length of from thirty to fifty million

THE NUCLEI OR HEADS OF FOUR OF THE MOST FAMOUS COMETS

The comets appeared in 1858, 1861, 1874, and 1882, in the order shown.

miles, and few, at their greatest length, fail to reach ten million miles. The mere volume represented by these measurements is enormous, exceeding by hundreds or thousands of times the volume of the sun.

But the mass or weight of these bodies is in comparison very small indeed. They are of such exceeding tenuity that when passing in front of the faintest star the tails of comets have never been found to diminish the star's brightness in the slightest degree. The head, or coma, is equally transparent, with the exception, probably, of the nucleus. Another proof of the extraordinary tenuity of comets may be found in the fact that, although comets have

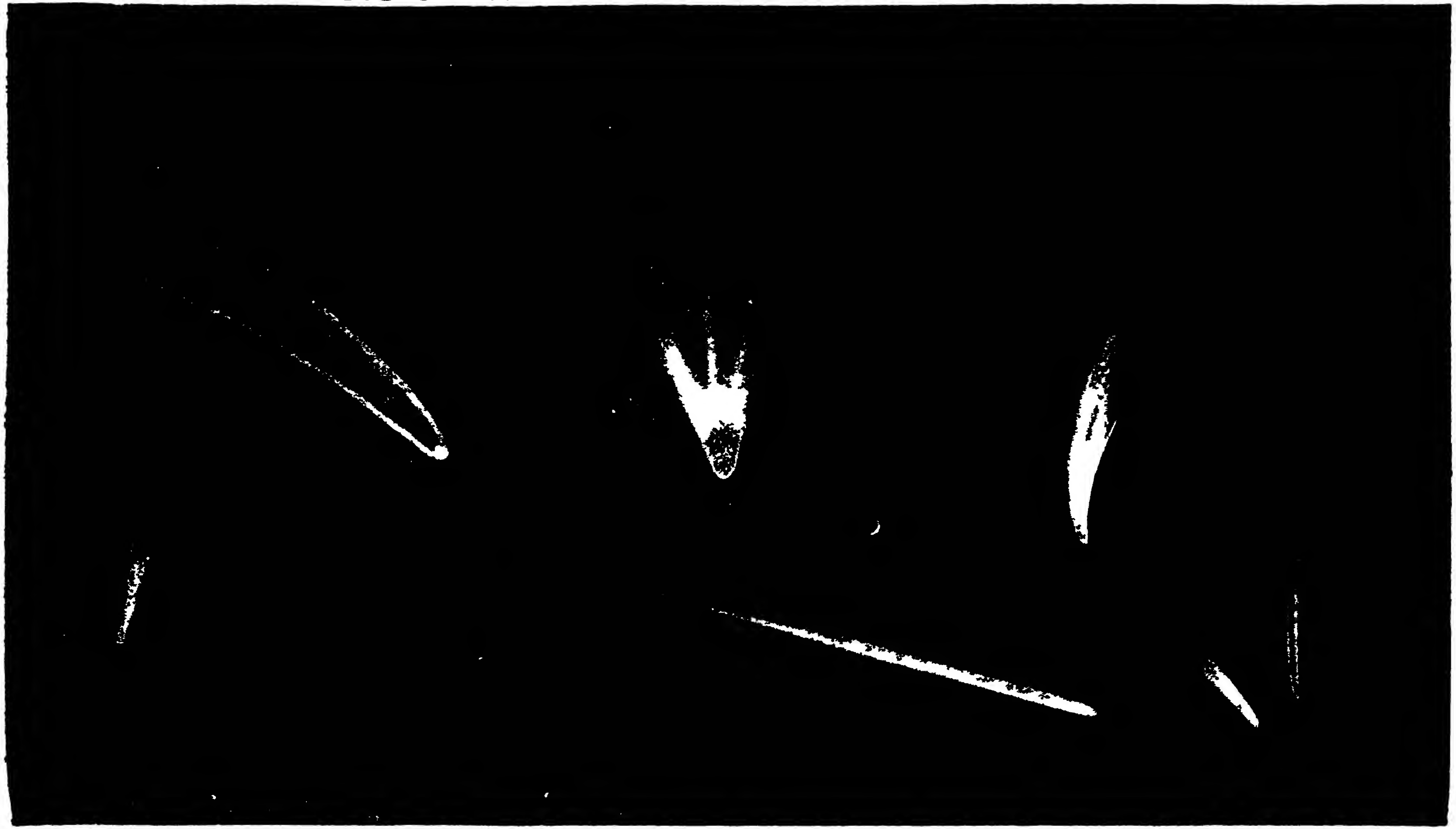


THE ELLIPTICAL ORBIT TRAVERSED BY HALLEY'S COMET EVERY SEVENTY-FIVE YEARS

passed quite close to various planets, and our earth has passed right through the tail of at least one comet, these delicate glittering things have never had the slightest appreciable effect upon the solid bodies they have approached or encountered. So far as the most exact measurements and calculations can go, a comet has never pulled a planet in the least degree out of its orbit, nor hastened nor retarded it.

The effect of a planet upon a comet, on the other hand, is often sufficient to alter its orbit entirely. Since no effect whatever has hitherto been observed to be produced by a comet upon any other body, it is impossible even to conjecture any estimate of the smallness of its mass. We know at least that the mass of a comet must be very much less than one-hundred-thousandth part of the mass of our earth, for, otherwise, appreciable effects would have been produced by comets upon planets they have approached. It may be difficult for us, who are used to observing the motions of bodies only under the conditions of our atmosphere, to conceive how a body having such incalculably small density can move with such tremendous velocity as is shown by comets in their swiftest career; it would almost seem that these vast, filmy objects, weighing next to nothing, must be stopped at once. But we must remember that in general, throughout interplanetary space, there is no resisting medium. When the air is withdrawn from a bell-glass, and a feather and a bullet are released within it, the one falls to the bottom as quickly as the other. Where there is no resistance, a comet, which is far more insubstantial than mist, may travel

WANDERING FIRE-MISTS OF THE HEAVENLY DEER AS SEEN FROM LONDON IN 100 YEARS

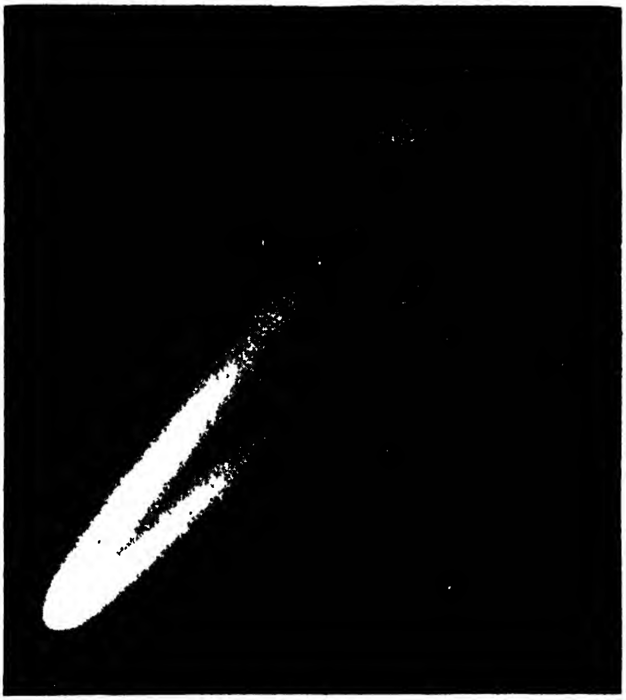


THE SEVEN MOST CELEBRATED COMETS SEEN IN THE BRITISH ISLES SHOWING THEIR IMMENSE SIZE AS COMPARED WITH THE MOON

as swiftly and as freely as the solid earth. The tail of a comet does not, as we might be inclined to suppose, trail after the head, as a train of smoke trails after a locomotive engine. It lies in a certain definite direction, which depends on the comet's position relatively to the sun. It points always away from the sun, and is undoubtedly driven away by some influence from the sun. The tail, therefore, follows the head when the comet is approaching the sun, but precedes the head when the comet is receding from the sun. Yet the tail is not usually quite straight, but describes a visible curve, convex to the direction of the comet's motion. This, at least, is the usual curve, but there are variations; for example, the curve of the tail of the 1910 comet lay concave to the direction of motion.

There are also two other types of tail, one or other of which is not unfrequently seen together with the usual great, plume-shaped tail. One of these is the long, straight ray-like tail, usually very faint; the other is the short, brush-like tail, very strongly curved, which was seen as the secondary tail in the new comet of 1910. The whole subject is still obscure, but there is little doubt that these three different kinds of tail consist of three different kinds of material.

It is generally believed that the tail of a comet is hollow, forming a hollow cone, and that it consists of solid particles, probably extremely small in size, each surrounded by a gaseous envelope. These particles are expelled from the nucleus, and are acted upon by some repulsive force from the sun. But besides these two repellent forces they are influenced also by the gravitative forces of the sun and of the nucleus. The effective result of all these forces, which produces the form of the tail, is due to the proportion the respective forces bear to one another; and this proportion, in its turn, depends upon the nature of the particles that form the tail.



THE COMET OF MAY, 1901, AS SEEN IN TWILIGHT
Photographed at the Royal Observatory, Cape of Good Hope.

Bredichin, a Russian astronomer, brought forward a very ingenious theory which has thrown some light upon the perplexing question of the tails of comets. He supposed that the repellent force of the sun acts only upon the *surface* of the particles, and that its power is consequently proportional to the surface of the matter upon which it acts. The gravitative force of the sun, on the contrary, is proportional to the *mass* of the matter upon which it acts, and is quite irrespective of the extent of surface. The effective force, on this theory, would evidently depend upon the ratio the surface of the particles bears to their mass. If the particles had a large surface in proportion to their mass they would be repelled more powerfully than if they were of denser material, and so had a smaller surface in proportion to their mass. But it has been found that the molecules of hydrogen, of hydrocarbon gas, and of vapour of iron bear to one another such a relation in respect of this ratio of surface to mass as would produce the respective forms of the three types of tail. Professor Bredichin therefore supposes that the long, straight tails are composed of particles of hydrogen; the great, plume-shaped tails of some hydrocarbon gas; and the short, violently curved tails of iron vapour, probably with some admixture of sodium and other materials.

Spectroscopic tests have more or less supported Bredichin's theory, though they are not conclusive in the matter. The spectroscope has shown the presence of hydrocarbon in some plume-shaped tails, but analysis of the light from the tail of Halley's and

other recent comets has shown that hydrocarbons are only variable constituents of comets, because the characteristic band of hydrocarbon gas is only an occasional feature of their spectra. The spectrum of the tail has been reproduced in that of carbon monoxide at very low pressure, while the same gas at a higher density gives a spectrum very similar to that of the heads of comets. A great deal of thought has been given to the question of the nature of that repellent force from the sun which is chiefly responsible for the form and movements of a comet's tail, but beyond the fact that it is due to some form of electrical energy there is little agreement on the subject.

The belief that the tail consists of matter ejected by the nucleus is supported by many observations of the activity displayed by the nucleus under the influence of the sun. This activity is greatest when the tail is being most highly developed. The matter thus thrown off by the comet, to form the tail, must be eventually lost, leading to the gradual diminution of the comet, and perhaps at last to its total disappearance.

The source of the light of comets has been much discussed. Do they shine by some intrinsic light, or by reflected sunlight only? The answer is that while the comet's light does depend, in some degree, upon the sun, it is not merely reflected sunlight. Two facts prove the dependence on the sun for light. In the first place, the light which we receive from the comet is partially polarised, showing that it is, in part, reflected light. In the second place, the comet diminishes in brightness as it recedes from the sun; whereas if it shone only by its own light it would grow smaller as it recedes, but would not diminish in brightness.

On the other hand, the comet's light is partially generated by itself. Spectroscopic examination proves that it is not merely reflected light. But the same fact is shown also much more clearly by the capricious changes which take place in its brilliancy, quite independently of its position in relation to the sun. A comet is sometimes seen to flash out with seven or eight times its normal splendour, and then after some hours to return to its normal brightness, or perhaps below it. These sudden variations, for which no external cause can be traced, reveal the presence of some inherent light, produced from the materials of the comet under the influence of the sun.

THE MOREHOUSE COMET ON OCTOBER 3, 1908

Little is known, after all, with regard to the constitution of comets. But the discovery in recent years of a very close relationship between comets and swarms of meteors goes far to support the conclusion, already adopted by astronomers, that a comet is an enormous collection of small, solid particles, probably quite minute in size, separated widely from one another, and each surrounded by a gaseous light-producing envelope. The most striking evidence in support of this relation between comets and meteors is the history of Biela's comet.

This was a small comet, visible only with the aid of a telescope, having a short period of about six and a half years, and was first observed in 1826. It was again seen in 1832, but was not seen on its return in 1839, owing to its unfavourable position in the sky. In 1846 it presented at first the ordinary appearance, but on December 19 it was seen to be somewhat pear-shaped, and by the 29th of the same month it had divided into two separate comets. For four months or longer the two companions were observed to travel side by side, at a distance of about 160,000 miles from one another, each having a bright and very active nucleus. There appeared to be no

attraction between the two, nor any perturbing action of either upon the other, but it was noticed that when one grew brighter the other became fainter, in a curiously alternating manner. For part of the time an arc of light connected the two.

In 1852, the date of the next return, both comets were seen, at a distance of about 1,500,000 miles apart. Neither of them has since then been seen, although if they had duly returned they must have been easily observed on several visits. On November 27, 1872, as the earth was passing across the path of this comet, she came into a remarkable meteor shower; and on crossing the same path again in November, 1886, a similar shower was encountered. There can be no doubt that these meteors bear some relation to the lost Biela's comet; and the simplest explanation seems to be that they are actually the disintegrated particles of the comet itself.

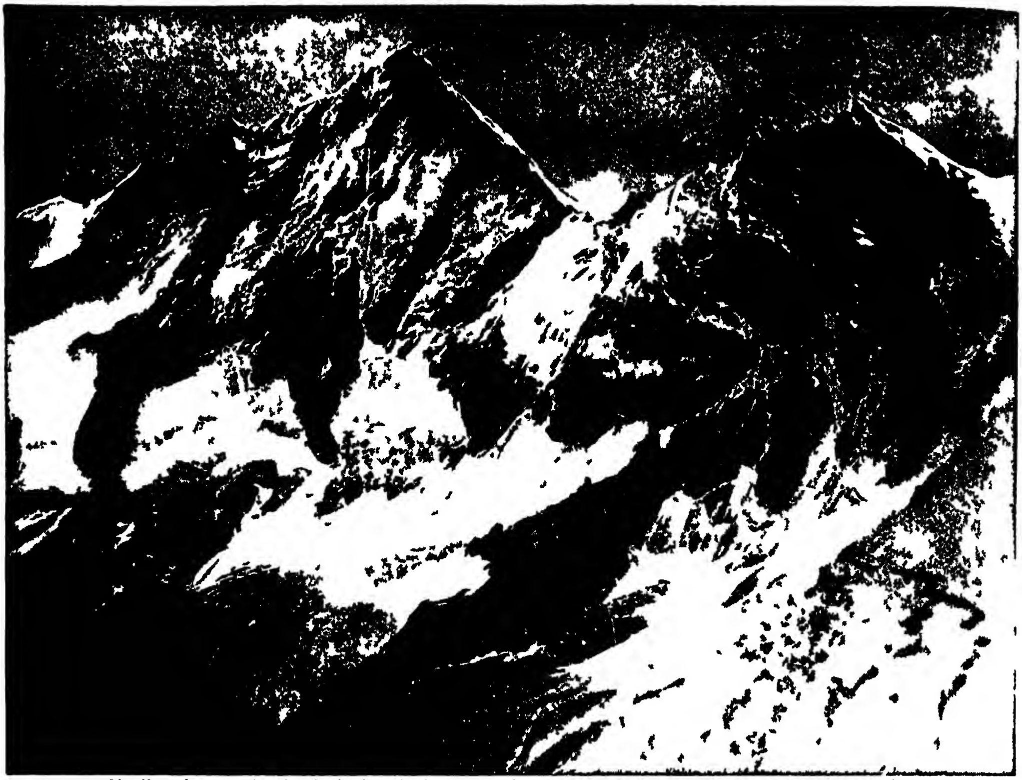
The most striking comet of recent years was the great comet of 1882, which showed many curious and unusual features, and was, besides, of exceptional beauty and brilliance. Its light was so powerful that it was clearly visible in broad daylight, even when quite close to the sun. It remained visible from September, 1882, to March, 1883, and was seen with the telescope to a distance of more than 470,000,000 miles from the earth, so that astronomers, were able to determine its orbit more accurately than usual. It moved in a very elongated ellipse, with a period of about 750 years. The nucleus was particularly interesting. At first almost round in form, it became elongated until it had assumed the shape of a long streak with several bead-like enlargements upon it, one of the beads being five thousand miles in diameter, and exceedingly bright. The chain of beads lengthened until it extended over a distance of one hundred thousand miles. The tail of this comet was at one time more than one hundred million miles in length, and was marked by a bright streak along its central line, extending from the bright chain of the nucleus.

THE MOREHOUSE COMET AS IT APPEARED ON NOVEMBER 16, 1908

A comparison of this photograph, taken by Mr. E. E. Barnard at the Yerkes Observatory, and that on the opposite page, taken at the Royal Observatory, Greenwich, shows the alteration in the form of the tail.

An unprecedented feature of the comet was a broad beam of faint light which enveloped the head and projected straight in front of it for several degrees. At least two observers saw on one occasion a second comet accompanying the great comet at a short distance; and this is supposed to have been given off from the great comet—a conclusion which appears to be supported by the history of Biela's comet.

DEFIANT CLIFFS LONG UNSUBDUED



The Weisshorn, 14,804 feet high, first climbed in 1861 by Professor Tyndall, and the Leishorn to the right

The Pigne d'Arolla, 12,470 feet high

Mount Pelvoux, 12,976 feet high

SOME TYPICAL EXAMPLES OF ALPINE MOUNTAINS WITH EXCEPTIONALLY STEEP GRADIENTS

Photographs by Donald McLeish

THE MAKING OF MOUNTAINS

Some of their Features—Their Age, Their Steepness, and How Fast they are Made and Unmade

CYCLES OF DECAY AND CONSTRUCTION

To the unscientific mind, as we have said, mountains are the symbols of immensity and immutability. Yet to science they are neither very large nor very lasting; they are little more than mud-pies, at the mercy of the rain.

As Bonney points out, on a globe a hundred feet in diameter, modelled to scale, Mont Blanc would be represented by an eminence less than half an inch high, and Mount Everest by an eminence less than an inch high; while on an ordinary school-globe, two feet in diameter, "all the inequalities of the land surface would have to be sculptured in the thickness of an ordinary playing-card." Seen thus in their true proportions, mountains are reduced to very insignificant rugosities on the surface of the earth.

When we begin to estimate their possible and probable longevity, too, we find that they are not everlasting, that they have comparatively a short lease of life. Some have calculated that even the great rampart of the Andes will be all worked away in nine million years; and nine million years in the life of the world are less than a watch in the night.

If the unscientific mind exaggerates the immensity and immutability of mountains, no less does it exaggerate their steepness. We often talk of almost perpendicular slopes, but as a matter of scientific fact very few slopes are steeper than an angle of 30 degrees, and those steeper than 40 degrees consist usually of bare rock.

Yet though science has corrected these illusions, science still retains a reverence for mountains as rocky records of mighty constructive and destructive forces that have moulded and are still moulding the earth, and finds in the making and unmaking of mountains a key and clue to the general mechanism of terrestrial change.

A most interesting and fascinating question to science is how mountains were made. Small though they be in comparison with the bulk of the earth, ephemeral though they be in comparison with the æons the earth has existed since it bore the moon and collected the sea, yet they are definite structural facts that require explanation, and must be made to fit in to any theory of earth-origin and earth-growth. What made these ridges and roughenings on the surface of the world?

Let us, in the first place, look at the general geological character of mountains and mountain ranges. A little observation reveals some most remarkable facts. We discover that three kinds of mountains may be distinguished. Firstly, mountains such as Roraima, which seem to have been been formed by the action of the rain washing away the soil all round them. These may be called mountains of denudation. Secondly, mountains such as Vesuvius, which are formed mainly of volcanic material. These may be called mountains of accumulation. Thirdly, mountains such as the Himalayas, which are built up out of sedimentary rocks. These may be called mountains of elevation. Of the three classes, the third is much the most important, for all the great mountain chains consist of mountains of this kind. It is the sedimentary mountains that we must explain, if we are to explain the mountain systems of the earth at all.

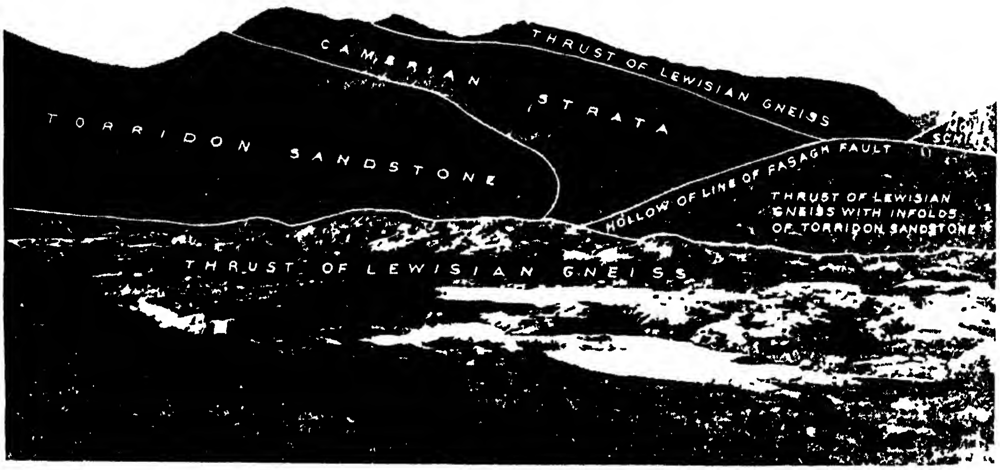
The sedimentary nature of the great mountain ranges is a most amazing discovery, for it means that these mountains—the Alps, the Himalayas—were once at the bottom of the sea. So amazing is it that only the most conclusive evidence could gain credence for the fact. But the evidence is most cogently conclusive. There can be no doubt about it. The great mountain

chains are composed of layers of sediment that at one time must have been deposited on the bottom of the sea. Not only do they display a stratification—a series of layers that can only be explained as the result of a precipitation through water—but many of them, as we have already stated, are built up out of the lime and shells of sea organisms, or contain certain fossils of sea creatures. Marine fossils have been found 10,000 ft. high in the Alps, 11,000 ft. high in the Rockies, and 16,500 ft. high in the Himalayas.

We start, then, with the very amazing fact that most mountains are made out of sediment deposited at the bottom of the sea. Now, all the sediment that falls to the bottom of the sea, whether lime-shells, or silica, or anything else, has been carried into the sea by rivers, and the rivers must have eroded them from previous hills; and so we reach the second amazing fact that the rivers not only wear down mountains but carry the material for new mountains. Just as certainly as all the bricks in a house were carted to its site, so certainly did the rivers convey to the sea the materials of the mountains. The rivers gathered the material for the shellfish that make up the cliffs of Dover; the rivers gathered the materials that make Mount Lebanon, and Mount Everest, and Mont Blanc; and every cubic inch they must have obtained from previous mountains of previous and vanished worlds. What cycles of destruction and construction there must have been !

Remembering what we have already seen of the destructive energy of rivers and glaciers; remembering that the Ganges and the Brahmapootra bring down over six million tons of mud yearly, and the Mississippi about six times as much, we can more or less easily believe that in time enough sediment even to make the thousands of miles of Andes and Himalayas would be precipitated to the bottom of the sea. The difficulty begins when we try to understand how and why the tremendous load of sediment was forced miles up into the sky, how and why all this mass of mud should be " first with the whales, then with the eagled skies."

When we examine these sedentary mountains, we find that the various layers of sediment are almost always bent, crumpled and broken. Originally, when deposited on the bottom of the sea, they must have been flat and horizontal. Now, we find them tilted up, even till vertical. We find layers that once must have been undermost uppermost; we find layers broken and their ends displaced for hundreds, perhaps thousands, of feet; we find, in fact, every kind of distortion and displacement. It is evident, therefore, that the sedimentary layers must have been elevated by very violent forces—forces sufficient to crumple and bend and break and displace layers of solid rock. Most mountain ranges, moreover, show signs of having been several times down among the whales and up among the eagles, for we find layers of sediment that have been precipitated horizontally upon the other layers. which have

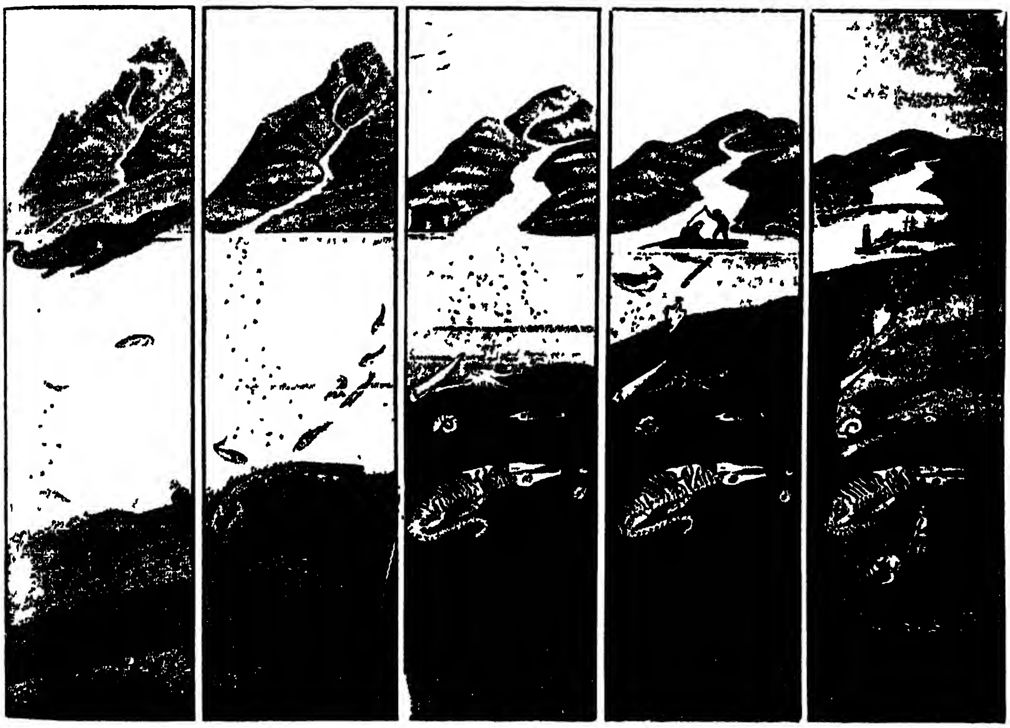


THE EFFECTS OF THE EARTH'S SHRINKAGE—THE THRUST OF LEWISIAN GNEISS OVER CAMBRIAN STRATA AT MULLACH COIRE MHIC, FHEARCHAIR, ROSS

been crumpled, and displaced, and broken. All the evidence points to repeated subsidences and elevations. How are we to account for these elevations and subsidences, and for the violence that caused and accompanied the movement? How are we to account for the crumpled layers of Mount Everest and Mont Blanc emerging from the ancient Tethys Sea?

There is nothing to suggest that the stratified rocks have been bent and crumpled into mountain ranges by any internal violence acting upwards in a vertical direction; in fact, the crumplings and foldings of the rocks are of such a nature as to negative such a supposition. Everything suggests that the rocks have been bent and crumpled by lateral pressure, much as we might crumple a tablecloth by moving the right and left index-fingers together over it, so as to kink and crumple the cloth between them. Sir James Hall illustrated the process by putting layers of cloth under a weight and then applying lateral compression. The result was crumplings closely resembling those of the Silurian strata of the Berwickshire coast. Professor Fabre, of Geneva, fixed some layers of clay upon a tightly stretched band of indiarubber, and demonstrated that when the band of india-rubber contracted the layers of clay showed contortions and inversions and dislocations quite like those of a great mountain chain. Mr. H. M. Cadell further elaborated the experiment by using layers of plaster-of-Paris, sand, and clay, and reproduced crumples and dislocations resembling those seen in the rocks of the N.W. Highlands of Scotland. Other experimenters have used other materials, but all have succeeded in producing most significant miniature models of mountain plications.

Lateral pressure, then, is admitted to have caused the crumplings of the earth's crust, and the consequent elevation of mountain ranges. So far, there is no difference of opinion, and no difficulty. Differences of opinion and difficulties begin when we endeavour to find the precise cause of the lateral pressure. In a general way, the cause of the lateral pressure is a shrinkage of the earth's interior owing to loss of heat through radiation. Since the crust does not shrink correspondingly, it becomes too large for its shrunken contents, with the result that lateral pressure is produced, followed by folding and crumpling. It has been estimated that the crumpled folds



TRANSMIGRATION OF MOUNTAINS. THE WORK OF A RIVER IN DEPOSITING MATERIALS ON THE FLOOR OF THE SEA FORMING A STRATUM AND IMBEDDING EXTINCT ANIMALS

A PANORAMA OF WELL-WORN MOUNTAINS IN NORTH BRITAIN, ORIGINALLY FORMED

of the Alps represent a shrinkage of seventy-four miles in the earth's circumference; that the crumpling of the coast range of California represents a shrinkage of ten miles; and that to produce all the mountain ranges the earth's circumference must have shrunk about two hundred miles altogether. The lateral pressure produced by such shrinkage must have been very great, since we find in places gigantic horizontal displacements whereby large mountainous masses of the terrestrial crust have been thrust over younger formations, in some cases for miles. The force of the pressure, too, is shown by the fact that clays and sands in the centre of the folds have been converted into hard, crystalline rock.

DIAGRAM OF AN ANTICLINE

Granted that the mountainous corrugations of the earth's crust have been produced by enormous lateral pressure due to shrinkage, it still remains to inquire why the earth's crust buckled at these particular parts, and why the buckling parts were so often submarine. Why were these parts squeezed into corrugations, and apparently repeatedly squeezed into corrugations? The wrinkles on an apple due to contraction radiate about in all directions. Why are the mountain wrinkles of the earth displayed in certain definite lines? It seems rather a begging of the question simply to say that the mountain chains and continental areas were lines and patches of weakness in the earth's crust. What we wish to know is just why the crust was weak enough in certain places to buckle into mountain chains and continents.

One most interesting suggestion was made by Professor George Darwin. Professor Darwin pointed out that the earth was originally more flattened at the Poles, and that as it became more spherical the crust would necessarily become too large for its contents and would shrink. He pointed out, further, that a shrinkage due to this cause would place most of the mountain chains within the zone of the equatorial bulge. He explained the direction of the mountain chains as the result of lunar tide influence, and rotation, which together would exert a screwing action on the earth's crust, and produce corrugations at right angles to the direction of greater pressure. "In the case of the earth, the wrinkles would run north and south at the equator, and would bear away to the eastward in northerly and southern latitudes, so that at the North Pole the trend would be north-east, and at the South Pole north-west. Also, the intensity of the wrinkling force varies as the square of the cosine of the latitude, and is thus greatest at the equator and zero at

BY THE THRUSTING AND FOLDING OF TORRIDON SANDSTONE AND CAMBRIAN STRATA

the Poles. Any wrinkle when once formed would have a tendency to turn slightly, so as to become more nearly east and west than when it was first made."

Interesting as this theory is, it is hardly quite satisfactory, since the forces Professor Darwin invokes could have acted effectively only in the youth of the world, and before the time of the making of modern mountain chains. Moreover, the theory does not account for the evident relationship between sedimentation and mountain-formation. Millions of years of sedimentation preceded the emergence of the Alps and Carpathians and Himalayas from the Tethys Sea. The three great upheavals in the North American continent, known as the Huronian, Animikean, and Keeweenawan, were the resurrection of sediment 18,000, 14,000, and 50,000 ft. deep respectively. "The region," says Dana, "over which sedimentary formations were in progress in order to make finally the Appalachian range reached from New York to Alabama, and had a breadth of 100 to 200 miles, and the pile of horizontal beds along the middle was 40,000 ft. in depth. The pile for the Wahsatch mountains was 60,000 ft. thick, according to King. The beds from the Appalachians were not laid down in a deep ocean, but in shallow waters, where the gradual subsidence was in progress; and they at last, when ready for the genesis, lay in a trough 40,000 ft. deep, filling the trough from brim to brim."

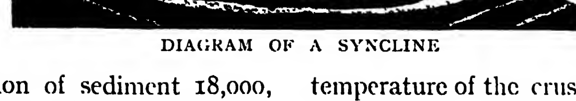


DIAGRAM OF A SYNCLINE

The Laramie range, again, was reared from sediment 50,000 ft. deep. Whatever, then, the explanation of mountain chains may be, it has to account for their sedimentary antecedents. A very interesting attempt to show the causal connection between mountain formation and sedimentation was made by Babbage. According to this theory, the heaping up of sediment on the ocean floor must cause a rise in the temperature of the floor, since we know that the temperature of the earth increases with depth. A thousand feet of rock, for instance, on the ocean floor, would raise the temperature of the crust below it by about 20 deg. Fahr. For like reasons, the denudation of the land must lower the temperature of the continental crust. The buckling of the sedimentary layers, then, according to this theory, is due to the enfeeblement of the submarine crust by superheating. Some geologists have added to this theory the supposition that the load of the sediment actually depresses the ocean floor, and that the denudation of the mountains leads to a rise of the unloaded continental crust; but, as Geikie remarks, "to suppose that the

removal or deposit of a few thousand feet of rock, such as the mass of a mountain belt like the Alps, should so seriously affect the equilibrium of the crust as to cause it to sink and rise in proportion would evince an incredible degree of mobility in the earth which would surely be manifested in other directions."

On the surface, Babbage's theory is plausible, but it will not stand examination. After all, the sedimentary layers of the ocean floor merely replace in position, as surface layers, the igneous layers, and are exposed to practically the same heat. Why, then, should they bend and buckle under lateral pressure? A modification of Babbage's theory was proposed a few years ago by Mr. Mallard Reade. He supposes that the sediment plastered on the floor of the sea acts like a strip of non-conducting material on the surface of a cooling ball of metal, retaining and raising the heat of that part of the earth's surface which it covers, and being in time heated itself above the average temperature of the crust. The excess of heat makes the sediment and underlying rock tend to expand. Expansion laterally and downwards is impossible, so it expands upwards, as a cake expands upwards on being baked, and the result is the mountain ranges and continents now being worn down.

FOLDING AND CLEAVAGE OF TORRIDONIAN SLATES AND HARDER BANDS AT TRAIGH BHAN, ISLAY

The flaws in this theory are that it does not account sufficiently for the lateral pressure which has certainly been at work on the mountains, and that the cause it supposes is not commensurate with the effects. As Bonney remarks: "The folding of a chain like the Alps is so marked, and its scale so gigantic, that the difference of temperature and consequent expansion which would be produced by the accumulation on that area of a few thousand feet of rock seem quite inadequate as a cause."

Yet another modification of Babbage's theory has been suggested by Professor Joly, who calls radium to his aid. Professor Joly has shown, by actual estimates of radium, that "in the deposition of sediments—their uplifting into mountain chains, their subsequent removal, and their re-disposition elsewhere—there is a continual convective movement of radio-active materials on the surface of the earth. Around the margins of all the great continents, where the sedimentation necessarily takes place to the greatest extent, the result of this convection is the accumulation of vast amounts of radio-active materials." And he holds that the accumulated radio-active material in the sediment is sufficient to raise its temperature, and to render it more liable to corrugation under the lateral pressure of the contracting earth. He calculates that a deposit only four kilomètres deep reduces the effective strength of the earth's crust by 10 per cent. He sums up the matter with regard to mountain elevation thus. "The whole theory is of the simplest kind. Given a stressed crust and a local source of heat applied above, while the normal heat of the earth flows upwards from beneath, and the area where these conditions exist must necessarily become the first place of yielding and flexure, as naturally as the rupture of the chain occurs at the weakest link. Under these conditions accordingly, we find, associated with great accumulations of radio-active sediments, bending and fracture of the crust, with the attendant phenomena of earthquake and volcanoes."

It is certainly a most fascinating theory. However the mountain chains were raised, one thing is quite certain, and that is that in their original condition they must have been very unlike the mountain chains now. They must have been very much less picturesque, and much more like the long linear corrugations we see on plate of corrugated tin. There must have been long level ridges, the anticlines, alternative

DESERTED BOUNDARIES OF AN EBBING SEA

ON AN ANCIENT SEA-LINE, NOW 700 MILES INLAND, SKIRTING THE COLORADO DESERT

SEA-WORN CAVES IN THE SANDSTONE OF A RAISED BEACH IN FIFE

with long valleys, the synclines; and, of course, at first they would be bare rock, without grass, or tree, or heather to break their brown and grey undulating monotony.

It is difficult to realise how much mountains have altered since their birth. Not only are the ranges now cut up into peaks of all shapes, but they are not half so high as they originally were! Wind and rain, frost and snow, have been at work for thousands of years, and the wear and tear has been tremendous. From the ancient mountains of Wales fifteen or twenty thousand feet have been removed. From the mountains in the Lake District, and from part of the Appalachian range of mountains in America, no less than twenty-six thousand feet — about five miles, that is to say — have been worn away. Above the Simplon at one time there was a sedimentary layer at least fifty or sixty thousand feet deep. The Laramie range in America would be 32,000 to 35,000 feet high to-day if they had not been eroded away.

It is an interesting fact that the original ridges or anticlines wear away much faster than the troughs or valleys or synclines between them. The reason of this is that the layers in a syncline are arranged like a pile of saucers set one within the other, right side uppermost, while the layers in an anticline are like a pile of saucers piled upside down. It is plain that the anticlinal arrangement is much more easily broken up than the synclinal, because in the synclinal arrangement the saucers hold each other together. So much more rapidly are anticlines eroded than synclines that in some cases the original relationship of anticline and syncline is reversed, and the syncline becomes the mountain crest and the anticline the valley. In the case of the Appalachian mountains, for instance, this reversal has occurred, and the mountain summits are synclines and the valleys anticlines.

ANTICLINE OF MILLSTONE GRIT NEAR TENBY

It must be noticed that the rate of denudation of mountains of elevation, and the shape to which they are worn, depends not only on the direction of the strata composing them, but also on the material of which they are composed. Limestone rock is comparatively quickly worn away, and assumes rolling curves, or in some instances takes the shape "of ruined masonry, suggesting crumbling battlements and tottering turrets." Granite does not resist denudation so well as might be expected; it has chinks in its armour in the shape of horizontal and vertical joints, and is often worn into great square blocks. Granite mountains have rarely sharp, jagged peaks; they are nearly always rounded and massive. Most of the high, sharp, jagged peaks are composed of gneiss and mica schist. All the aiguilles of the Alps — the Wetterhorn, the Matterhorn, the Weisshorn, the Aiguille Vert, the Aiguille des Charmoz, Dent du Midi, Dent de Morcles, etc. — are produced by the weathering of gneiss and mica schist.

When we say that a certain mountain range has been worn down for 10,000 ft., it does not necessarily follow that the mountain tops are 10,000 ft. nearer sea level, for in many cases as the top of the mountain is worn away its base is elevated and thus the mountain, despite great denudation, may remain about the same height. Even at the present day such a compensatory rise is known to be taking place in various parts of the world. The greater part of Scandinavia is slowly rising out of the sea, at the rate of a few feet a century, so that in some districts the pine-trees have been lifted into regions of perpetual snow and have been killed by the cold; while round the lakes of Southern Sweden are found oyster-shells that have once been in the sea. In Scotland there are numerous raised beaches, sometimes

one above the other, to the height of 75 ft., testifying to rises of the land; in Cornwall and Devon similar raised beaches are found; and there is a famous raised beach in North Wales 1357 feet high. Nova Zembla, Spitzbergen, Siberia, Northern Greenland, the western coast of South America, New Zealand, Japan, all show signs of upheaval. Accordingly, even still the mountains in many lands are slowly being upraised, and it is possible that even still elevation more than compensates for weathering and denudation.

We have not yet considered the question of the rate of the uprising of the great mountain chains. Did they uprise gradually and slowly, as Scandinavia has been rising for the last few hundred years, or were they upheaved with volcanic violence all of a sudden? In some instances earthquakes have been known suddenly to raise and depress large areas of land to a quite considerable extent. After an earthquake in 1822, the coast of Chili was upraised for three or four feet; and after an earthquake in 1762, sixty square miles of land were suddenly submerged in the sea. Did the Alps and Himalayas rise slowly inch by inch from the bottom of the sea, or was their upheaval a matter of a few minutes?

Probably the elevation of the mountains was intermittent, and at times steady and slow, like the elevation of Scandinavia, and at times sudden and paroxysmal, like the elevation of the Chilian coast. The tremendous crumpling and folding of the rocky layers of the mountain chains certainly seems to indicate violent and paroxysmal upheavals, but, on the other hand, there are proofs that great elevation must have occurred gradually without any violence at all. An instance of this quiet elevation is seen in the elevation of the Uinta Mountains, which was so gentle "that the Green River, which flowed across the site of the range, has not been deflected, but has actually been able to deepen its cañon as fast as the mountains have been pushed upward." And in the Himalayas "rivers still run in the same lines as they occupied before the last gigantic upheaval of the chain."

Mountain chains, then, probably rose, as a rule, gradually, with occasional paroxysms of violent and rapid upheaval. And now all these modern mountain chains are being gradually deposited as sediment in the sea, and in time the sediment will again be raised into new mountain chains. The Amazon, the Mississippi, the Brahmapootra, and all the great rivers are all busy mountain-making. Many of the processes of Nature exhibit a cycle of destruction and construction, but none is more dramatic than the cyclical destruction and construction of mountains. Think of it! Mud at the bottom of an ocean rising inch by inch, foot by foot, till eventually it is a mighty range of snow-clad peaks, and then the great peaks, inch by inch, foot by foot, are eroded away, and collect as mud to await new reconstruction!

ANTICLINE IN COAL MEASURES IN COURSE OF EROSION NEAR SAUNDERSFOOT, PEMBROKESHIRE

DEADLY WEAPONS OF MAN'S INSECT FOE

THE HEAD AND MOUTH PARTS OF THE FEMALE MALARIA MOSQUITO, ANOPHELES

The mouth parts are here shown separated but in their natural state they are all perfectly arranged in the proboscis like a [illegible] of surgical instruments. The upper lip is seen on the left and the lower on the extreme right between these are the thread like [illegible] and two hairy palps The whole group, when closed, constitute the proboscis—highly magnified In the top right hand corner [illegible] picture is shown a tip of one of the lancets magnified in area 25,000 times, this photograph showing the barbs

These photographs are by Mr J. J. Ward

MAN AND THE MOSQUITO

The Story of the War Waged by Men of Science of All Nations Against Malaria

DEFEATING AN ALLY OF BARBARISM

We have already seen that the powers of Life have manifested themselves, above all, in the insects, with their instincts, at the head of the invertebrate world, and in man, with his instincts and his intelligence, at the head of the vertebrate world. No actual "struggle for life," of any importance, exists between man and the highest insects, the social hymenoptera, such as the bees. But among other insects we now begin to find the chief effective enemies of man, apart from such microbes as that of tuberculosis. Further, we find that the insects which man has most to fear are not deadly in themselves, though undoubtedly parasitic upon his blood, but injure him, as it were, accidentally, because of certain minute parasites which make hosts for themselves, both of man and of the insects. Thus the "struggle for life" and the "balance of Nature" take on most complicated forms, which we require to unravel, first for their inherent interest; and second, because our life and death, health and disease, success and failure (as in trying to sever continents), are so intimately concerned.

Here, again, Louis Pasteur was the pioneer. In the 'seventies of the nineteenth century he established in Paris the school of thought and practice which led the way to conquests of which even he could scarcely dream; and just as Sir Frederick Treves has said that our own Lord Lister, the greatest of Pasteur's disciples, won for Japan her war with Russia, as we shall see, so it may be said that Louis Pasteur dug the Panama Canal. Let us trace the sequence of events.

Robert Koch, the German, was the pupil of Pasteur, as we saw, who discovered the microbic parasite of tuberculosis, a discovery from which is now surely proceeding the extermination of that disease. All parts of the civilised world sent their representatives to the Pasteur Institute in those days, but France herself was not lacking. Thus, a French Army surgeon—as he then was—took the opportunities which were before him in North Africa, and began to hunt the blood of malaria patients, in the hope of finding some causal parasite, such as his Master was finding in other diseases. M. Laveran's work was not unrewarded, and he duly found a parasite which was invariably present in all cases of malaria. His Algerian work, with this result, was published in 1880, a memorable date, in his book, "La Paludisme." Paludism (that is, marsh-ism) was, and is, indeed, the technical name for malaria, indicating its almost invariable origin in connection with marshes.

But this great book on "marsh-ism" gave us a new conception of the disease, and of the appropriateness of its name, or names. The word "mal'aria" is obviously nothing but Italian for "bad air." Now, marshes, especially at night, beget a "dangerous night-air," or "miasm," which may seem to be the cause of the illness which often attacks dwellers on marshes, just as "sewer gas" was thought to be the cause of puerperal fever, typhus, and typhoid. But Pasteur's pupil showed us that, in fact, the disease "ague," malaria, so-called, or paludism, so-called, is not due to bad air, is not due to marshes, but is due to a living parasite which multiplies in enormous numbers in the blood of the patient, destroys his red blood-cells, produces poisons, and so causes the well-known symptoms of the disease.

The parasite, illustrated on page 2956, is not a vegetable, like the bacilli of tuberculosis and so many other diseases, but a minute animal. As it inhabits the blood of man, it may be spoken of as a hæmatozoon, or blood-animal. It is one of the great group

of animal forms which the zoologists call the "protozoa," or "first animals," the humblest group that they know.

It occurs in the blood of man in various shapes and states, some of which are specially characteristic of one type of malaria, and others of other types. For the acute attacks in this disease occur at different intervals in different cases, so that we used to speak of "quotidian fever," "tertian fever," "quartan fever," according to the number of days elapsing between the febrile attacks.

The Life-Cycle Within Man of the Malarial Parasite

We now know that these differences depend upon the particular variety of parasite with which the patient has been infected, and that in certain types of the disease the symptoms are due to a double infection with two varieties of the parasite, each going through its own life-cycle at its own rate.

It has further been found –to complete our initial account of the parasite itself–that this humble organism, contrary to all expectation and previous zoological experience, is sexual, or, rather, that its life-history comprises a sexual stage. Two forms, male and female, each consisting of only a single cell, can be identified, so that here the distinction between the *soma*, or body. and *gamete*, or germ-cell, between the individual and the race, does not exist. The generations follow one another with extreme and, for the unfortunate host, disastrous rapidity; and the birth of each new generation of young forms in the blood of the patient appears to coincide with the production of certain poisonous substances, which show their power by the production of a fresh attack of shivering and fever for the unhappy victim.

The Parasite that Causes the Greatest Amount of Illness and the Drug that Checks It

The malaria parasite has a wide distribution upon our planet. The disease it causes is the most common, though tuberculosis is the most deadly, to which man is subject. Undoubtedly this parasite causes more illness than any other. If we include certain of the lower animals within our purview—as is well worth while, we shall discover—we find that closely allied forms of parasites, cousins, so to say, of our own, inhabit the blood of other creatures, causing similar symptoms in them. Conspicuous in this relation is the avian malaria which attacks various species of birds, and which helped us to discover what is so essential for any success against malaria.

Perhaps one should not say "any success," for that is to do less than justice to the wonderful drug quinine. The bark of the cinchona, often called "Jesuits' bark," in honour of those who first popularised its use, contains various peculiar alkaloids, and, above all, the one called quinine, which can enter the blood, when a preparation of the bark, or of the alkaloids themselves, is swallowed, and can there kill the malaria parasite, in the great majority of cases. That drug has saved untold myriads of lives, and has very valuable uses against malaria even today. But on all grounds it is better not to have the parasite in one's blood at all.

How, then, does the parasite get there, and what part do the marshes play in "paludism," and the air which comes from them at night in "malaria"? The association is unmistakable, and has been recognised from the most ancient times. A precise explanation of it would surely give us the means of abolishing malaria wherever we chose to do so. At this point we must turn apparently aside, in order to review, very briefly, another aspect of the history of our subject, and fulfil an imperative duty by giving honour where honour is due.

London and Liverpool Leaders in the War with Malaria

First, as to the men whose co-operation has given us the knowledge which is about to be detailed. We have already named Pasteur and Laveran. There follows Sir Patrick Manson, for many years medical adviser to the Colonial Office. In 1897 he demanded special education in Tropical Medicine in our medical schools. Only six months later, Mr. Joseph Chamberlain, then Secretary for the Colonies, wrote to the medical schools on the subject; and in the autumn of that year, 1898, the London and Liverpool Schools of Tropical Medicine were founded, the latter being greatly indebted to its first chairman, the late Sir Alfred Jones, to whom we are also largely indebted for that excellent foodstuff the so-called banana from the West Indies. At the head of the London School was Sir Patrick Manson, and the Professor of Tropical Medicine at the Liverpool School was, and is, Sir Ronald Ross. These two pioneer schools, rightly established in the land which is responsible for such a vast Colonial Empire in varying climates, have done magnificent work in the fourteen years since they were established.

There have been martyrs to science, also. The London School lost the son of its head.

Dr. Manson, who died through accident while on an expedition, and who had previously submitted himself to a crucial experiment which proved the now long established theory of the transmission of the malaria parasite. The Liverpool School lost Dr. Walter Myers, who died of yellow fever contracted while he was studying that disease at Para; and Dr. Everett Dutton, who died of relapsing fever in Central Africa while he was studying sleeping sickness. Let these names be duly recorded and honoured among those who have lived and died for mankind.

Some Allied Investigators who Helped with the Work Abroad

Mr. Chamberlain was not content with the founding of the two schools in 1898. He wrote to Lord Lister, then President of the Royal Society, asking the Society to send a special expedition to study malaria and its congeners in West Africa, and this was done in 1898, since when the Royal Society has continued its work in this direction. Sir David Bruce set the Army Medical Department going on similar lines; Paris, Bordeaux, Hamburg, and Washington have followed; Dr. Andrew Balfour is doing splendid work in the Wellcome Research Laboratories at Khartoum; and other laboratories have been started in India and Australia. The foregoing brief historical summary is much indebted to the admirable book, "Mosquito or Man? The Conquest of the Tropical World," written by the late Sir Rubert Boyce, F.R.S., who was Dean of the Liverpool School, and who played a great part in the investigations of the present century. His recent and untimely death was a great loss to science, but in his work and his book he still lives, and may continue to serve mankind.

The Scientific Capture of the Tropics from Insect Pests

He concludes his historical chapter with the following memorable words.

"In the study of tropical medicine—that is to say, by the study of a wider medicine as distinguished from the parochial, local, or older form—nations possess a force which above all others can wrest vast provinces from the sway of the insect pests which, though minute in size, yet in their aggregate mass have defied and hurled back man when he has ventured into their domain, or completely wiped out those who tried to gain a foothold.

"The narrative would appear more like a fairy tale were it not based upon easily accessible reports and figures."

So much for the external or public aspect of our history, and now for its scientific aspect. We left the development of knowledge at the great discovery, published in 1880, of the parasite of malaria, and we wondered how it reached the blood of man.

A few wise men had guessed the truth, long before the parasite was known. In an Eastern work on medicine, fourteen hundred years old, it was stated that malaria is carried by flies or mosquitoes. Early in the nineteenth century an American doctor blamed mosquitoes for both malaria and yellow fever. But the Frenchman Dr. Beauperthuy is the real pioneer. In 1853 he sent an essentially complete account of the truth to the French Academy of Sciences, asserting that mosquitoes inoculate man with malaria and yellow fever; that these diseases are not contagious; and, as for marshes, that "marshes do not communicate to the atmosphere anything more than humidity, and the small amount of hydrogen they give off does not cause in man the slightest indisposition in equatorial and inter-tropical regions renowned for their unhealthiness. Nor is it the putrescence of the water that makes it unhealthy, but the presence of mosquitoes."

Obstinacy and Ignorance of Officials in the Presence of Scientific Inquiry

We owe to Sir Rubert Boyce the discovery of Beauperthuy's place in this regard, and may accept his opinion that scientific proof has never more completely verified the guesses of a man of patience and genius than in this instance. But patience and genius are rare, and indolence and acceptance of what has long been asserted are common. Only a few years ago the present writer heard Sir Ronald Ross lecture on malaria; and at the end of his demonstration a most distinguished Colonial governor, who need not here be named, discussed the matter with contempt and contumely, pouring scorn on the whole theory, of which he was no more competent to judge than an infant. A year or two later, at the Royal Institution, Sir Ronald Ross had to show how the carelessness and so-called scepticism—it is not scepticism, for that means "looking about"—of officials were responsible, as they are now responsible, for a vast and constant toll of wholly preventable deaths, as, for instance, in India, where several millions of deaths yearly are due to malaria, and where, hitherto, nothing whatever has been done in the way of an anti-mosquito campaign. And Beauperthuy's paper goes back to 1853!

Ignoring other steps in our knowledge, we come to the notable suggestion and demonstration, made by Sir Patrick Manson in the early 'eighties, that a certain worm disease, called filariasis, is due to the bite of the female mosquito, since it was found that the mosquito is the "intermediate host" of the parasitic worm in question. Briefly, it suffices to say that many creatures, such as the filaria (and now, as we know, the malaria parasite), pass the cycle of their lives in two stages—the first in an animal of one species, and the second in an animal of another.

Manson's Study of the Worm that is Carried to Man by the Mosquito

Thus, the trichina worm lives in the pig and in man, as the great Virchow first showed in Germany; and every succeeding step in our knowledge has added to the importance of these peculiar life-cycles, in the case of many parasites—above all, where one of the hosts is man.

We may feel little interest in filariasis, but the worm which causes this disease is a curse of the tropics, infecting half the population of China in some parts, for instance. Early in the 'seventies, Sir Patrick Manson, who was then in Formosa, tried to puzzle out the facts. Another observer had traced the disease to the tiny worm, the filaria. Manson went back to China, and continued his study and speculation. What could possibly convey this worm to the blood? Might it not be something capable of piercing the skin, taking some blood, containing the worm, and then transferring it to another person? The only likely or imaginable agent was the mosquito. So he made a test, getting a Chinaman who had filariæ in his blood to be bitten by mosquitoes. and then examining them. The filariæ were found in the stomachs of the mosquitoes, and not dead, but alive and active.

Sir Ronald Ross's Discovery of How Mosquitoes Convey Malaria from Man to Man

Finally, Sir Patrick Manson traced certain changes and peregrinations of the filariæ, until they reached the sheath of the mosquito's proboscis, whence they were injected into the blood of a fresh patient. This shows us finally that " man harbouring the parasite is the reservoir, the mosquito is the carrier of the parasite. . . . The parasite passes part of its existence in man, and part in the mosquito; both man and the mosquito are necessary for the complete development of the parasite. Therefore, if the mosquito is destroyed, the life-cycle of the parasite is destroyed, and the disease must of nece sity cease."

In 1897 Sir Ronald Ross discovered the parallel fact for malaria. " A water-breeding mosquito sucked, not decomposed vegetable or animal matter at the marsh, but the blood of a man suffering from malaria, and in which there were parasites in abundance. The parasites sucked in with the meal of blood underwent further development in the mosquito—*i.e.*, infected the mosquito; and then when the *infected* mosquito, which had now become the *carrier*, bit man, it *infected* him." Simple, is it not? But this true theory of such diseases built the Panama Canal, and is changing the face and destiny of the world. Let us have the facts in the discoverer's own words, and then, if the reader will, he may read in the discoverer's published poems the noble set of verses which he composed when the " million-murdering " cause was so promisingly revealed to him in the body of the mosquito.

After discussion with Sir Patrick Manson, Ross went back to India, and began hunting for Laveran's parasite in the bodies of mosquitoes. Nothing came of it. But at Secunderabad he noticed a special kind of mosquito, not the ordinary, too familiar "Culex," and it occurred to him that he must systematically look for the parasite in every kind of mosquito that ever bit man.

Ross's Researches Respecting the Presence of Malarial Parasites in Mosquitoes

Working eight hours a day at his microscope, under cruelly difficult conditions of heat and persecution by flies, he went steadily on, and found nothing. But he persisted, though almost blind with his work, and finally he was rewarded.

" On August 20th I had two remaining insects, both living. [They were insects which were known to have bitten malarial patients.] Both had been fed on the 16th instant. I had much work to do with other mosquitoes, and was not able to attend to these until late in the afternoon, when my sight had become very fatigued. The seventh dapple-winged mosquito was then successfully dissected. Every cell was searched, and to my intense disappointment nothing whatever was found until I came to the insect's stomach. Here, however, just as I was about to abandon the examination, I saw a very delicate circular cell, apparently lying amongst the ordinary cells of the organ, and scarcely distinguishable from them. Almost instinctively I felt that here was something new. On looking further, another and another similar object presented itself. I now focussed the lens

carefully on one of these, and found that it contained a few minute granules of some black substance, exactly like the pigment of the parasite of malaria. I counted altogether twelve of these cells in the insect, but was so tired with work, and had been so often disappointed before, that I did not at the moment recognise the value of the observation. After mounting the preparation, I went home and slept for nearly an hour. On waking, my first thought was that the problem was solved, and so it was."

He traced the development of the parasite within the mosquito, and by means of special staining he showed how the parasite produces spores, and traced their course. Here are his words. "The exact route of infection of this great disease, which annually slays its millions of human beings, and keeps whole continents in darkness, was revealed. These minute spores enter the salivary gland of the mosquito, and pass with its poisonous saliva directly into the blood of man. Never in our dreams had we imagined so wonderful a tale as this."

SIR RONALD ROSS

Photo by Elliott & Fry

For this discovery, in especial, Ross received the Nobel Prize some years later. Meanwhile his work had been confirmed. In 1900, mosquitoes were conveyed from the Campagna, in Italy, having first sucked up a meal of blood from a malaria patient. Under the direction of Manson, two gentlemen, one of them his own son, offered themselves to be bitten by these mosquitoes, neither of these gentlemen having ever been out of England Young Dr. Manson contracted malaria, and parasites of the same type as in the Italian case were found in his blood. He was "cured" with quinine, but had a recurrence about a year later—some parasites had been in hiding in his body meanwhile.

As Sir Rubert Boyce summarised the matter—"This experiment demonstrated that a person could contract malaria in London, where epidemic malaria does not exist, provided that he was bitten by *infected mosquitoes.* Ross had now, therefore, worked out the whole story. The mosquito was the carrier of malaria *from man to man.* Malaria had no connection with miasms. The reason why malaria was associated with marshes and water was simply that mosquitoes bred there."

Until this discovery, man's sole weapon against malaria was quinine. This drug usually cures, and it may be used so as to prevent, being taken regularly in comparatively small doses, so as to keep a certain proportion in the person's blood, against the arrival of any possible parasites. This "quinine prophylaxis"—*i.e.*, prevention—is still a useful weapon, but a more evident one is to destroy the mosquito. If the problem were to exterminate all mosquitoes, it would be a well-nigh impracticable one, but Ross was very soon able to show why he had so long met with unsuccess. He had spent nearly all his time upon kinds of mosquito in which the parasite cannot live. Many mosquitoes bite, but the only kinds which can become infected belong to a particular group, of which the general name is Anopheles or the Anophelinæ. To exterminate the anophelines is by no means impossible, if we set about it rightly. But the method is all-important; and it applies no less at our own doors than in the tropics, for we have flies to fear for very similar reasons, and our first impulse is to say "Kill that fly," and to proceed accordingly.

A hundredth part of the labour will have a hundred times more effect if we proceed on sounder biological lines. If we want to increase the number of a species, such as our own, we must care for the young, the parents, the homes; if we want to reduce the number of a species,

such as flies or mosquitoes, we must attack the young, the parents, the breeding-places. Special inquiry has been made into the habits of anophelines, and we know exactly what the problem is. The male anopheline matters not. He has no lower jaw, cannot bite, and is exclusively a vegetarian. The female alone concerns us, for she alone bites us, and can harbour the parasite. She "breeds in small collections of water—those with a natural earth bottom, such as small pools and patches of water of all descriptions, margins of streams and lakes and odd receptacles coated with humus"—that is to say, with decomposing vegetable matter and soil.

How Mosquitoes Have Been Entirely Banished from Panama

In the first place, then, let mosquito-nets be used; let us dose ourselves with quinine; and let us avoid going out into the "dangerous night-air," for it is in that air that the female mosquito flies when she is hungry. But if we attack pools, by whatever means we think fit, we shall reduce the number of mosquitoes indefinitely. If we do our task well enough, all other precautions are superfluous. Dr. Leigh, the venerable Dean of Hereford, lately told the present writer that when he was at Panama, in the autumn of 1911, there were no mosquito-nets in use at the hotel, for there were no mosquitoes. That is why there *is* a canal. And, since no useful method must be ignored, let us observe that the indigenous population of a malarial region harbours the parasite to an extraordinary extent—80 to 90 per cent.—without showing any particular symptoms. These "healthy reservoirs" become the source of infection for anophelines breeding in small collections of water in the neighbourhood, and these infected anophelines soon bite any newcomer and infect him.

A Summary of the Means of Defence and Offence Against Malaria

The lines of defence and offence against malaria can now be defined; and here they are in the words of Sir Rubert Boyce.

1. Measures to avoid the human reservoirs—
   (*a*) By means of segregation;
   (*b*) By screening with nets those suffering from malaria.
2. Measures to avoid the anophelines—
   (*a*) By choice of suitable locality, when possible;
   (*b*) Screening houses (windows and verandahs);
   (*c*) Sleeping under mosquito-nets.
3. Measures to exterminate the anophelines—
   (*a*) Use of the natural enemies of mosquitoes;
   (*b*) Use of mosquito-killers, such as paraffin;
   (*c*) By drainage and scavenging, to get rid of breeding-places;
   (*d*) Penalties for harbouring larvæ or keeping stagnant water;
   (*e*) Education.

The substance of modern treatises on malaria prevention cannot be compressed into this chapter, but the foregoing table comprises the whole of the measures which, between them, or portions of which, have already abolished the disease in various parts of the world. Here we need only specially refer to a few points of general scientific interest. The first has reference to the natural enemies of the mosquito, and here our Darwinian studies come to our aid. We have seen what the "balance of Nature" means, and Darwin has taught us how the numbers of species are kept down by the existence of other species. He has also taught us that the immature are by far the easiest victims.

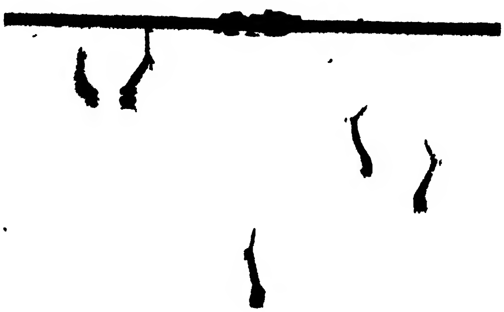
Natural Enemies of Mosquitoes that Should be Cultivated

So here, doubtless the adult mosquito has its enemies, such as birds, but it is the larvæ that perish most abundantly, and their great enemies are fish; or, to put it in another way, the natural food of many fish is the larval form of the mosquito. Thus, in Barbados there are no anophelines and no malaria, though the other West Indian islands are plagued with the disease. Yet Barbados abounds in swamps and ponds. The inhabitants are protected by a tiny fish, so numerous as to be called "millions," a kind of "toy minnows," which live near the surface of the water, and whose staple diet is the larvæ of mosquitoes, if any there be. Sir Rubert Boyce went to Barbados and confirmed the truth of this theory, then propounded by a resident, Mr. Gibbons; and now the Imperial Department of Agriculture is introducing the beneficently hungry Barbados "millions" into other mosquito-plagued islands.

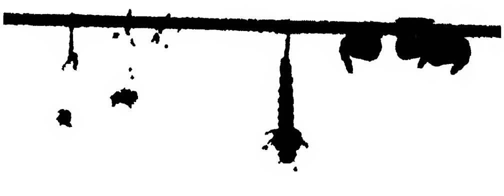
At one time the use of kerosene was much advocated, for this oil forms a film on water, and prevents the larvæ from reaching the surface to breathe. In certain cases this is a useful method, but, as Ross has often declared with splendid force, the

proper method is to drain puddles and swamps and pools, so that these shall not abound in the very midst of tropical towns as still too often they do. Now let us try to summarise results as hitherto attained. In his great book "Researches on Malaria," Ross has an eloquent passage—this man of genius is a poet, a mathematician, a microscopist, as well as a doctor—in which he states the facts of the past. Malaria, he says, "strikes down not only the indigenous barbaric population, but, with still greater certainty, the pioneers of civilisation—the planter, the trader, the missionary, and the soldier. It is therefore the principal and gigantic ally of barbarism. No wild deserts, no savage races, no geographical difficulties, have proved so inimical to civilisation as this disease. We may also say that it has withheld an entire continent from humanity—the immense and fertile tracts of Africa; what we call the Dark Continent should be called the Malarious Continent; and for centuries the successive waves of civilisation which have flooded and fertilised Europe and America have broken themselves in vain upon its deadly shores." The difference between mankind in Africa and in Europe today is probably due to the malaria-bearing mosquito alone.

In Italy the campaign against malaria was started in 1902, and in seven years reduced the annual mortality from about 16,000 to about 4000. In the plain of Marathon, in Greece, thanks to Ross, in two years the proportion of all sickness due to malaria fell from 90 to 2 per cent. And Ross significantly adds; for those who mistake the true spheres of international competition, that "the best kind of international race is that in which nations compete to benefit humanity." Who is trying to win in this kind of "Marathon race"? The Suez Canal Company was cursed with malaria at Ismailia. Italian workmen employed in the construction of the canal probably came as reservoirs of the parasite, and the anophelines did the rest. In 1886 it was computed that every inhabitant suffered from the disease. As early as 1901 the company sought the help of Ross—many years before our Colonial governors and officials, with few exceptions, ceased to jeer and deny—and every breeding-place of the anophelines was abolished. From 1905 onwards *no case of malaria* has been reported in Ismailia; and the company hope to make a sanatorium and a healthy inland sea-bathing resort for the inhabitants of Cairo out of what was a mosquito-plagued town and a nest of malaria. Just so, the application of knowledge in man's struggle for life against the insect and the protozoon is rapidly turning the "White Man's Grave" on the West African coast into a health resort.

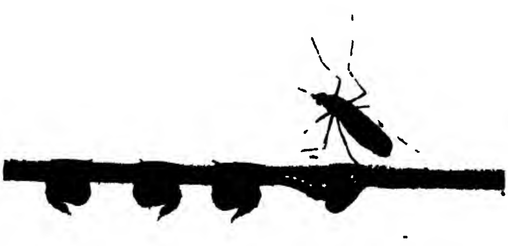


Egg rafts and half-grown larvæ of mosquitoes diving and breathing through the tube at their tail end



A full-grown larva breathing, moulted skins on the left, and emerged and active pupæ on the right

The emergence of a mosquito from one of the pupæ on the surface of the water



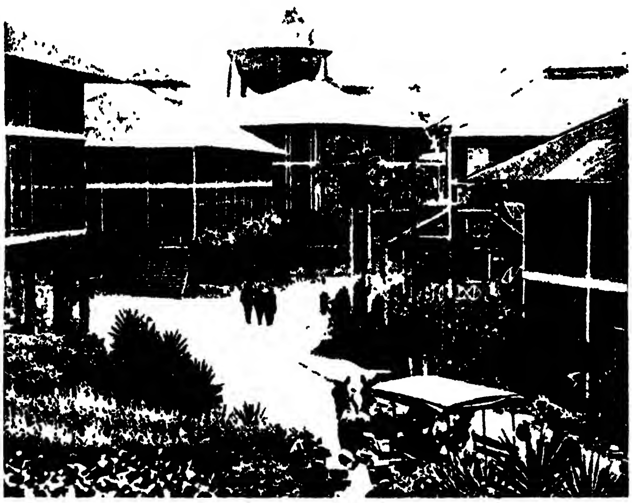
The mosquito fully emerged and about to take its first flight

STAGNANT WATER THE NURTURE-GROUND OF MOSQUITOES

At Port Said, Dr. E. H. Ross, brother of Sir Ronald Ross, started successful work in 1906. At Khartoum, Dr. Andrew Balfour began his work in 1904. The present writer well remembers Dr. Balfour as a fine footballer, who played "forward" for Scotland. Now he is playing "forward" still for man in the greatest game on earth. The report in 1909 runs: "He organised anti-mosquito brigades to examine all breeding-places, water receptacles, and pools, and then organised measures for drainage, oiling, etc. As the result of five years' work, Khartoum is declared almost mosquito-free, and primary cases of malaria are exceedingly rare." Great success has been attained in Algeria, where the problem of the native Arabs, who act as "healthy reservoirs" of the disease, has to be met.

Sierra Leone, the "White Man's Grave," was the first place chosen by Ross for a practical test of his theory. Magnificent success was attained. The African Association sent a cheque to the Liverpool School, as a "supplementary grant," "in recognition of the fact that 1908 was the first year in the history of the company in which there had not been a death in the whole of our Coast Staff." The mortality among native soldiers of the West Indian regiments serving on the West Coast of Africa was reduced by 75 per cent.

The French tried to build the Panama Canal, and retired, beaten by two kinds of mosquito, after a loss of fifty thousand men—and doubtless a little money. In 1904 the United States took over the Canal Zone; and the splendid men who do the official medical work of the States set to work, with a staff of two thousand. In 1906 the deaths from malaria were 821; in 1908 they were 282, or 1·34 per thousand, and the reader has lately been told what the Dean of Hereford found at Panama in 1911. Systematic drainage has been the method here, together with the use of petroleum in some places, and with the use of quinine as very subsidiary.



THE MOSQUITO-PROOF QUARTERS OF THE ENGINEERS OF THE PANAMA CANAL

In Colon, Rio de Janeiro, Havana, and Belize similar results have been obtained. The West Indies are now making good progress, with the usual quick and unmistakable results. The result of the Spanish-American War has been most remarkable, not only in Cuba, as we shall later see in reference to yellow fever, but elsewhere. Just as France failed at Panama because of ignorance which was certainly no fault of hers, for Pasteur was a Frenchman, and so is Laveran, but the mosquito had not then been incriminated—so Spain failed to hold her colonies because of ignorance in her case largely inexcusable. Ignorance of the laws of health destroyed the health and lives of 100,000 Spanish soldiers in Cuba in three years. The case was similar in the Philippines. Now the superb and unequalled health service of the United States Army is in charge of the health of Cuba and the Philippines, and everything is changed. The death-rate among the troops in Cuba and Porto Rico is practically the same as at home, and the death rate of the civil population in Manila compares favourably with the rest of the world. In Hong Kong and in some parts of the Malay Straits good work has also been done.

But what about India? On the occasion of the visit of King George and his Queen to India, Sir Ronald Ross and others made a public appeal for attention to the great problem of malaria in our vast dependency. In that great country some five millions of deaths are recorded every year from "fever," and the vast bulk of these are none other than malaria. As for the military population, it was recorded in a typical year that, out of a total force of 305,927, there were 102,640 cases admitted into hospital suffering from malaria. This is not a disease which suddenly and mercifully cuts off its victim, till then healthy, thus leaving

room for another healthy man to succeed him. On the contrary, it is a chronic, undermining, slow intoxication; and the net sum of its action within the body is to sap its victim of his energy. Above all, this disease attacks the power to work, the *economic efficiency*, of its victim. Where there are millions of deaths recorded annually, the sum total of sickness is huge probably seven or ten or more times as many are at any time suffering as in any year die. We have already asserted that malaria causes more sickness, though tuberculosis causes more deaths, than any disease in the world, and tuberculosis is chronic and cruel enough in its methods.

A BREEDING PLACE OF THE ANOPHELES MOSQUITO FREETOWN, PRIOR TO DRAINING THE TOWN

The problem of malaria in India is therefore not a matter of humanity only. It is a problem of national maintenance. Where such a disease as this infects a population, national power to live is as a whole impaired and crippled. Let us, if we will, ignore the deaths, and look only at the sickness. If recent historical students are to be trusted, the fall of Greece, as we shall see in another section of this work, was essentially due to the destruction of the energies of the Greek race by the introduction of malaria. Let us learn our lesson. Sooner or later this matter of malaria in India will have to be faced and dealt with. Men of genius—French and English and Scottish and American—have enabled man to become master of the malaria mosquito if, when, and where he will. In the case of India he *must* will. It is for us in this country a national duty to ourselves, to India, to the Empire, and to the world. The man of science, who has devoted his genius, his life, and his eyes to the problem, and who has already thereby saved hundreds and thousands of lives all over the world, makes his protest and demand in the name of knowledge and humanity, and it is simply forgotten. But he is not silent, nor are the few, the steadily increasing few, who have followed this inquiry from the first, either silent or likely to be silent.

The question which men of science, of humanity, of patriotism, now ask the British people and its representatives in India is—What are you going to do about malaria, which annually slays millions and cripples tens of millions in your Indian Empire, and which is easily and certainly and totally preventable whenever you say that you are ashamed to let it endure any longer? If the British Empire is to be justified by the only fruits upon which an Empire can continue to live, if we desire to make glorious for ever the reign of our King, let us take in hand this work, and justify the poet who said of England in danger that God would be the poorer for her overthrow.

INSIDIOUS FOES OF VEGETABLE LIFE

POTATOES IN SECTION, SHOWING VARIOUS STAGES OF DESTRUCTION CAUSED BY DISEASE

CATERPILLARS ON CABBAGE

THE CELERY MAGGOT

WIRE WORM ON LETTUCE ROOTS

HOW YOUNG PLANTS ARE ATTACKED BY SLUGS WHICH EAT THE EARLY LEAVES

ON THE BORDERLAND OF DESOLATION

AN ARAB OUTPOST KEEPING WATCH AMONG THE SAND DUNES OF TRIPOLI

DISEASE IN GARDEN PLANTS

The Insidious Foes of the Potato, Tomato, Celery, Gooseberry, Strawberry, and Currant, and How to Defeat Them

THE SYRINGE AS A WEAPON OF DEFENCE

In this chapter we propose to discuss some of the more important diseases which attack such edible plants, or portions of plants, as the potato, the tomato, the gooseberry, the currant, the strawberry, and celery, for all of these suffer from certain fungoid, or allied, conditions detrimental to the value of the crop.

Corky scab is a parasitic condition of potatoes which, although it does not actually destroy the whole tuber but only a portion of it, seriously interferes with its market value by producing an unsightly appearance. The condition is extremely common in Great Britain, Ireland, and Norway, three large potato-producing areas, and it is probably in existence, to a greater or less extent, wherever the potato is cultivated on a large scale. The word "scab," as applied to the potato, is used in different districts for several conditions which are not identical as regards their cause. In some places the result of eelworms and millipedes is thus referred to. But the true "corky scab" is due to a definite parasite termed *Spongospora scabies*, and closely related to the fungi.

The adjective "corky" is applied to this condition because the tissue produced round the affected area is of the nature of cork. The disease produces dark-coloured patches on the surface of the potato, usually restricted more or less to one part of it. Later on, the skin of this patch rises and bursts, much as a blister does, but the contents, instead of being fluid, consist of numbers of spores. Tubers thus attacked, if placed in dry soil, form a considerable amount of the corky material, and it checks the growth of the parasite; whereas if they are placed in moist soil the parasite continues to grow, and the corky layer is deferred in onset. This means that the parasite eats its way into the body of the tuber, producing a hole in which the spores form. The reason why the whole potato is not readily destroyed is because this parasite does not grow in the form of hyphæ, and so there is no mycelium produced. If there were, it would penetrate through the whole potato.

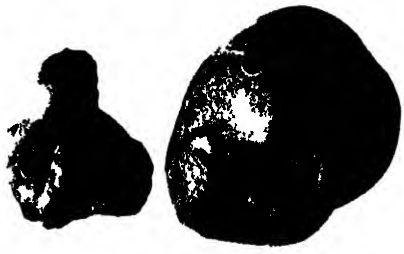
In no case should potatoes thus affected be used for seed. The parasite itself can be killed by soaking the affected potatoes in a solution of half a pint of formalin in fifteen gallons of water, but this, of course, will not kill spores implanted deeply within. The greatest care should be taken to see that the tubers affected with corky scab do not come into contact with healthy ones, or else the spores may be readily transferred from one to the other.

Bacteriosis of the potato and the tomato is a condition which, although known for some time in America, was first noticed in this country so recently as 1902, when it occurred in the North of England and in Scotland. The symptoms are first noticed in the topmost leaves, at or near the tip of the stem. As the disease gradually extends in a downward direction, the leaves first affected curl up and assume a yellowish appearance. Still later, in the tomato, blackish or brown patches appear on the leaves, and the stem itself becomes streaked with dark lines. A cross-section of the stem in both the tomato and the potato shows that the vascular bundles, or woody parts, are crowded with organisms which produce a brownish colour. Microscopic examination is, of course, necessary in order to observe this.

When the tomato fruit forms, it, too, shows dark patches, at first on the surface, but finally forming blister-like pits, which burst, and therefore render the injured fruit liable to further infection from all sorts of germs. The result is that the tomato

becomes absolutely useless. The infection gradually spreads right down to the roots, and the plant dies.

In the potato the bacteria travel downwards until they reach the tubers, which, on section, show a brownish ring; and a little distance within it the organisms are in abundance. From this position they gradually spread inwards, until the whole of the interior of the potato becomes discoloured and soft, and leaves nothing but an external shell. When the potatoes are taken out of the ground this shell is easily broken, and the millions of bacteria inside fall back into the land.



POTATOES AFFECTED BY CORKY SCAB

Since it is very easy for these bacteria in the soil to become attached to the seed when planted, and grow in the germinating seedling, it is important to note which are infected areas, and, if possible, to avoid cultivating thereon. In any case, seed from diseased tomatoes should not be used. In the case of the potato, it has been proved that the condition is spread by insects which pass from one plant to another. These insects themselves must therefore be attacked by spraying the leaves with the Bordeaux mixture referred to in a previous chapter, with an insecticide added to it. The following mixture is advised for this double purpose:

PARIS GREEN AND BORDEAUX MIXTURE

Quicklime	10 lb.
Bluestone (copper sulphate).. ..	10 lb.
Paris green.. ..	8 oz.
Water	100 galls.

BACTERIOSIS OF TOMATO PLANT

The Paris green in this mixture is the insecticide, and should be made into a paste with a little warm water, and stirred up in the mixture. In addition, care should be taken that no potatoes showing the brown discoloration within should be used for sets, and, if possible, none from an infected area. Further, the ground itself had best be treated with gas-lime.

Canker is a condition that was formerly known as being a serious cause of disease in melons in America, but it has recently attacked tomatoes and cucumbers in this country. The evidence of its presence is found at the point where the first leaf appears. It passes through a gummy, moist stage, to become hard and dark in colour, and later on almost white. The outer portion of the stem of the plant is then found to be covered with a number of little areas which contain spores, and the effect of the parasite is to produce the death of its host. Cucumber plants so attacked are soon killed; and it has been proved experimentally that the spores from them can attack tomatoes, and from the tomato spread to the vegetable marrows. The greatest loss amongst tomatoes is usually towards the end of July, when they are ripening.

There are still some important points to be ascertained in connection with this disease; but inasmuch as the disease so often starts in the tomato where the first leaf is nipped off or stopped, it is possible that the infection begins chiefly through wounds of this kind. It would therefore be a wise precaution to stop bleeding from such wounds. The plants may also be sprayed with Bordeaux mixture while they are young. Growers of tomatoes would do well to keep a keen look-out for the onset of this condition, because, though it may be easily stamped out at first, it becomes epidemic in a year or two, and requires stern measures.

A further disease of tomatoes, known as the septoria disease, appeared suddenly in this country in 1907 and 1908, and produced very serious damage. From the history of the condition, it has evidently spread as the tomato has been introduced from place to place. It is caused by a fungus that makes its presence known by

minute greenish-black spots on the leaves. These are soon killed and rolled up. The stem is also attacked, and, finally, the fruit; and if the disease be allowed to run its own course, the whole plant will be killed in about a week. In outdoor plants the fungus begins to grow in June and July. It produces a mycelium which penetrates into the leaves, and they dry up and become dark. A lens is required to observe the characteristic minute points on the surface of the leaf, from which a brown substance arises. This is quite typical of this disease alone. The black points are the reproductive part of the fungus, and the brown substance coming from them is a mass of spores.

TOMATO CANKER

Such great havoc is caused amongst tomatoes by this condition that no pains should be spared to stamp it out. Growers should be always watching for the appearance of the condition. If the plant is attacked, prompt spraying is the only way to save it; and for this purpose Bordeaux mixture may be used. But if they are badly attacked the only practical method is to carefully uproot them and burn them. It must be remembered that, as the leaves of the plant dry up, the spores fall to the ground, or remain adherent to the woodwork of the greenhouse. The soil itself should be mixed with fresh lime, and it would be a good plan to apply some lime to the ground when planting out young plants. As in other cases, seed from an infected area should not be utilised.

THE SEPTORIA DISEASE OF TOMATOES
1, leaf attacked by fungus; 2 and 3, magnified portions of diseased leaf; 4, section through leaf showing fruiting conceptacle magnified; 5, spores of the fungus, highly magnified.

Root-knot disease is another condition affecting tomatoes and cucumbers, and may be considered here, although it is not produced by a fungus, but by the root-knot eelworm. Its presence should be suspected when the plants show drooping, yellow foliage, a feeble stem, and a collapse of the plant. If the roots be examined, they are found to be covered with a number of knots of all sizes up to a quarter of an inch, or even larger; and if these be cut across and examined microscopically, they will be found to contain a number of minute worms, each measuring 1–75th of an inch in length.

The only treatment is to destroy the eelworms, either by saturating the soil with a solution of carbolic acid (one in twenty) in water, or the soil can be treated with gas-lime; but either of these procedures involves leaving the soil alone for a period of five or six weeks afterwards. Unfortunately, quite a number of other plants besides the tomato and cucumber act as hosts to this parasite. Amongst them may be mentioned clover, peas, beans, lettuce, potatoes, beet, and dandelions. So it is a very easy matter for the eelworm to spread from one place to another.

One may usually find examples of black-knot in gardens which are uncared for. It appears in connection with not only the gooseberry but red and black currants. The black areas are caused by a fungus which works its way into any wound on the stem of the plant. There it produces its spores, and soon is followed by a yellow appearance of the leaves. The wound through which the parasite gains an entrance is probably produced by one or other of the insects which attack the stem. During the first year the results are not so serious, but in the second season it is noticed that the leaf-buds do not open properly, and the branch actually dies, on account of the penetration into its vessels of the mycelium of the fungus. It is only when it is dead that the black, warty appearance is manifest on the outside. The only treatment is to ruthlessly

prune all affected branches and burn them, and keep the plants free from insects which may injure the covering of the stem.

"Cluster-cup" is a curious condition which appears suddenly from time to time on the gooseberry bush, and then vanishes without any apparent reason. When present, it is due to a fungus that causes a number of bright orange-coloured patches on the leaves and fruit of the gooseberry. These patches ultimately produce a number of spores. Only a part, however, of the life-history of fungus is passed upon the gooseberry, and in many cases a part of the life is lived on another plant. The only treatment is to cut off and burn the leaves and fruit showing the infection.

Brown scale of the gooseberry and currant may be mentioned here, although it is due to an insect, and not a fungus. The attack is made not only on the gooseberry, but the currant, the rose, the plum, and, rarely, the raspberry. It is confined principally to the older branches of plants growing in sheltered spots with a sunny aspect. It is common throughout England, but less so in other parts of Great Britain. Only the female insect is known. She produces hundreds of whitish eggs and then dies, and her body forms the "scale." From this the larvæ emerge and implant themselves among rough parts of the bark of the plants, where they pass the winter, becoming active again in spring. The brown scale can best be prevented by washing the plants in winter and spring, as it is during this time that the larvæ can best be attacked. The washing, however, must be done in a very thorough manner, in order to reach them. The solution recommended for this purpose is known as caustic soda wash, or the "Woburn Wash," and is made up as follows.

Sulphate of iron	½ lb.
Lime..	¼ lb.
Caustic soda	2 lb.
Paraffin	5 pints

Water to make ten gallons.

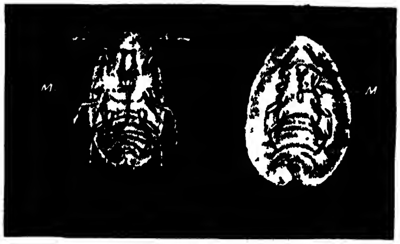
EELWORM NODULES ON A CUCUMBER-ROOT

For the spring washing it is recommended to make a paraffin jelly by boiling five gallons of paraffin and eight pounds of soft-soap together, adding a pint of cold water while boiling. When this sets, it forms a jelly, ten pounds of which in forty gallons of water can be used as a spray.

"Die-back" is a condition sometimes spoken of as the *sclerotinia* disease. It is extremely common all over Great Britain wherever the gooseberry is largely grown. The disease attacks the plant either in the branches, the stem, the new young shoots, the leaf, or even the berry itself. It is caused by a fungus, the mycelium of which grows right into the cortex, and, as the result, sooner or later makes the bark crack, and come away in pieces. The first point attacked is the part of the stem just out of the ground, and, as the result, the parasite is said to "ring" the stem. This ring has the effect of devitalising the whole tree. This disastrous result, however, does not follow for several years, but in the meantime the fungus has spread its ravages up the branches and to other parts.

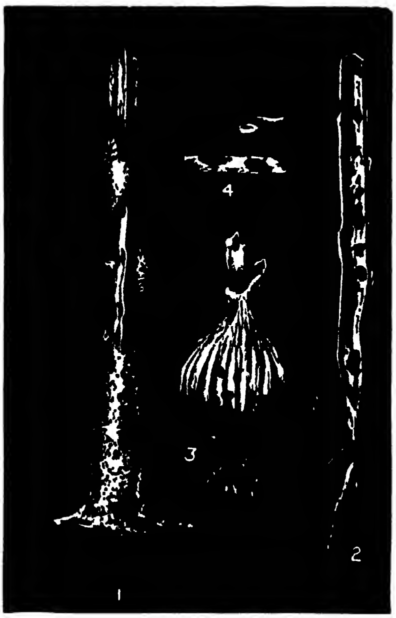
Perhaps the most characteristic and easily recognised sign of the existence of the sclerotinia disease is the occurrence of a few dead branches, perhaps to the extent of half the whole gooseberry bush, on the various plants. The fungus renews active growth with the advent of each spring, at which period the peeling off of the bark can be best noticed, and on the bark itself a number of small fluffy patches are scattered, consisting of the fungus. Often the trees die just after the leaf-buds appear, and in other cases when the berries are filling out. If a careful examination then be made, the injurious ring at the base of the stem will be found.

The disease on the leaves is seen by their yellow colouring at the edge, later becoming white, and encroaching on the leaf until it is all affected and falls off. Sometimes, however, the leaves remain only partially attacked. The fact that the young annual shoots of the gooseberry may also be the site of the disease is responsible for the local name of die-back, because these infected shoots soon die. One of the great dangers of the spread of this disase is in taking cuttings for propagating the plants. A case is recorded in which no less than 2000 young bushes just planted out actually all contained the fungus within them. The onset of the attack on the berry itself is noticed by the appearance of brown spots on the skin of the fruit, one side of which then becomes soft and discoloured, rotting absolutely away in the course of a week or so.



THE BROWN SCALE FOUND ON GOOSEBERRY AND CURRANT BUSHES
1, magnified larva; 2, under side of young female; (3) mouth parts.

In conditions such as this, heroic remedies should always be adopted. All dead bushes should be ruthlessly destroyed by burning; no prunings from the trees should be allowed to accumulate and so harbour the fungus. Directly any leaves are noticed to be affected, the whole tree should be taken up and burned; and if this radical treatment be adopted for a few successive seasons there is every prospect of stamping out the disease in the garden or plantation. It is most important to remember that the fungus lives not only on the growing bush, but as a saprophyte on dead portions of the trees. If it is impossible to remove all the affected bushes, then spraying must be resorted to, and this is best done before the buds burst, using a strong solution composed of four pounds of copper sulphate, dissolved in a hundred gallons of water. The leaves also may be sprayed with the Bordeaux mixture, care being taken to direct the moisture as far as possible to the under surfaces of the leaves.



THE SCLEROTIUM DISEASE
1, potato haulm with summer stage of fungi starting from the ground line; 2, section of haulm showing sclerotia within; 3, onion with sclerotia on its scales; 4, two forms of fruit.

Two kinds of mildew are known to attack gooseberry bushes, produced by two distinct fungi, known respectively as the American mildew and the European mildew. The latter has been harboured in Great Britain for a very long time. It attacks only the leaves, or, in exceptional cases, the tip of the fruit, being generally prevalent after a warm spring which followed by colder weather. Its appearance is that of a white dust on the plant. This is composed of millions of spores produced by the fungus, and is readily blown about and so infects other plants. As in some other cases, the later growth is of a black colour; and this black stage of the fungus lives over the winter and reinfects the plants in the following spring. The result to the gooseberry bush is that the fungus interferes with the proper functioning on the parts of the leaves, and so prevents adequate growth of the roots, a condition that in time may cause its death.

The American mildew does not restrict its attacks to the leaves, but also invades the fruit and the young growing shoots, on which it appears, by the growth of its mycelium, as a woolly covering.

Both forms of mildew may be treated by spraying the bushes with a solution of liver of sulphur in the proportion of one pound to thirty-two gallons of water. Needless to say that all the infected leaves, and other parts, should be destroyed by burning.

The appearance on the foliage of strawberries of strawberry leaf spot is too familiar to need detailed description, for almost all growers of this delightful fruit are familiar with the reddish-brown spots which make their appearance on the leaves from time to time. As these spots run together from peripheral growth, irregular patches are produced, which by and by become greyish-white in the middle and reddish at the edge. Hence the term given

to the condition in some places of "bird's-eye spot." In the middle we have the tufts of the fungus, and the spores remain on the leaves. All varieties of strawberries appear to be liable to this condition, but it may be well to mention that the variety known as the Royal Sovereign exhibits a special susceptibility to the infection.


STRAWBERRY LEAF-SPOT

Treatment resolves itself into spraying at an early stage of the infection with liver of sulphur in the proportion of one ounce to three gallons of water, or the Bordeaux mixture may be used as a spray also. Whichever is chosen, the spraying should be repeated until the plants are in flower. A very drastic procedure, but one which has been found to be efficacious, is to cut off all the leaves from the plants, after covering the fruit, leaving them *in situ*, covering with some straw, and burning the whole mass. It might be expected that this would result in killing the strawberry plants, but, as a matter of fact, new foliage springs up, apparently much benefited.

1, EUROPEAN; 2 AND 3, AMERICAN GOOSEBERRY MILDEW

The valuable celery plant is subject to various diseases which more or less interfere with its value. One of them is that known as the "celery leaf-spot." It was first recognised in America in 1891, and is now well known as a very destructive infection. It attacks the foliage, on which blotches of a brown colour are first of all produced. Afterwards they become more pale, and are seen to be dotted with minute black spots. As in other cases of leaf infection, these spots are found to be composed of masses of spores, which, when ripe, fall to the ground with the dead leaf, and in that way, of course, infect the soil for any future crop.

Another leaf disease of celery, also caused by fungus, gives the appearance of angular brown spots, with black dots on them, and frequently assumes an epidemic type among the celery plants. Both these forms of celery-leaf disease, however, can be prevented if the plants be treated sufficiently early with a spraying of the Bordeaux mixture, to which we have already referred several times. The spraying should be repeated for three successive weeks. Growers of celery should be ever on the search for the first appearance of this leaf disease, because the plants will never grow to the standard that they otherwise would attain if once the food-making capacity of the leaves is interfered with by this, or any other, parasitic infection.

Again, while we are dealing with the celery plant, we may introduce here our remarks concerning the condition caused by the larvæ of the celery fly. It attacks also parsnips, and causes great loss in both species of plants. These little creatures pursue their activities in connection with the leaves, in which they burrow to feed upon the juices. Naturally, the result is that the leaf shrivels up, and is of no further value to the plant. The latter being deprived of its leaf organs, fails to grow, and the celery produced is of a very inferior greenish colour and a bitter flavour.

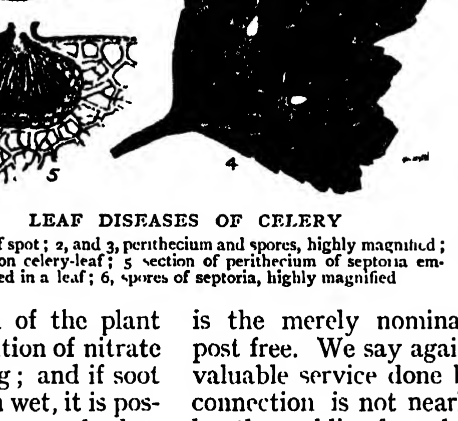
Another fly, known as the celery-stem fly, also damages the crop by its larvæ, forming burrows in between the stalks, as can be seen quite distinctly by the brown or rusty coloured

appearance. These flies lay their eggs on the upper aspects of the leaves of the two plants concerned. The eggs hatch in a week or so, and the larvæ at once proceed to work their way into the tissues of the leaf. In about another fortnight the larva changes to pupa, and in a few days more the fly itself hatches out.

After the celery crop has been taken out of the trenches in which it is grown, the top layer of soil should be deeply buried so that the pupa have no chance to develop further, or else the upper soil should be treated with gas-lime. The careless practice of leaving the leaves of celery or parsnip plants lying about is responsible for much spread of this condition. Such leaves should be either buried or burned; and, until this is done with regularity, celery and parsnip growers need not be surprised to find their crops infected. The growth of the plant itself can be aided by the addition of nitrate of soda, and repeated watering; and if soot be dusted over the plants when wet, it is possible that the eggs of the flies may be less frequently deposited. But the treatment of the leaves must be that of spraying, with, for example, a mixture of paraffin (one quart), soft-soap (half a pound), to ten gallons of water. Such a spray, applied lightly, prevents the flies depositing their eggs, and it should be applied when the plants are young.

LEAF DISEASES OF CELERY

celery leaf spot; 2, and 3, perithecium and spores, highly magnified; septoria on celery-leaf; 5 section of perithecium of septoria embedded in a leaf; 6, spores of septoria, highly magnified

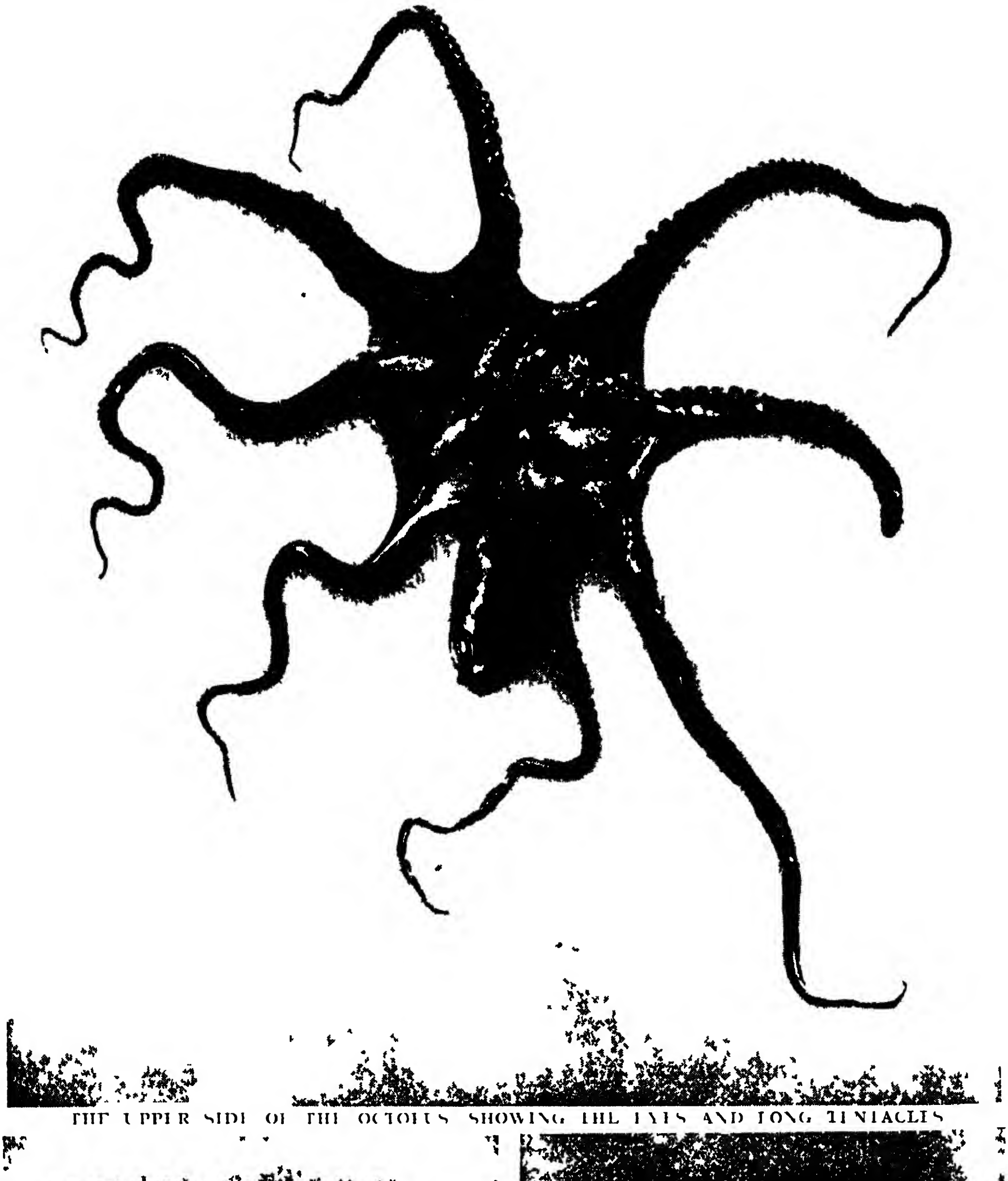


THE CELERY FLY WITH ITS PUPA AND LARVA

1, fly, magnified; 2, larva, magnified; 3, pupa, natural size.

We would take this opportunity of drawing the attention of our readers to the extremely valuable series of leaflets issued by the Board of Agriculture and Fisheries in connection with all the many and varied diseases which attack our plants and trees. These leaflets are not nearly so well known as they should be. They are drawn up by expert botanists and entomologists, who have made plants and their parasites their special study, and are written in a simple and non-technical form, so that any ordinary person can understand them easily. There is a perfect mine of information to be gathered from them, and they are at the disposal of anyone who chooses to apply for them. Single copies, dealing with any definite disease concerning which there is a leaflet published, can be obtained, free of charge and post free, by merely applying to the Secretary, Board of Agriculture and Fisheries, 4, Whitehall Place, London, S.W. Not only so, but the leaflets are issued in two bound volumes, each containing a hundred, and the price of each volume is the merely nominal one of sixpence, post free. We say again that the extremely valuable service done by the Board in this connection is not nearly so well recognised by the public, for whom it is done, as it should be; and it is a pleasure to be able to attract the attention of our readers to this further fund of information which is at their disposal, and from which many of the facts in these pages are taken. No one who has a garden, and still less those who gain a living, in whole or in part, from either vegetable growing or fruit culture, should fail to make these official leaflets the basis of careful study, for their science is thoroughly practical. In our next chapter we shall consider the best methods of defence for fruit crops.

THE EIGHT-ARMED MONSTER OF THE DEEP



THE UPPER SIDE OF THE OCTOPUS, SHOWING THE EYES AND LONG TENTACLES

FRONT AND BACK VIEWS OF THE OCTOPUS, SHOWING THE SUCKERS ON ITS TENTACLES

[illegible] that [illegible] Martin Duncan

WARRIORS OF THE OCEAN

Sharks and Dog-Fish, Rays, Sword-Fish, Squids, Octopuses, and Cuttle-Fish

THE TEEMING SEA-LIFE THAT FEEDS LIFE

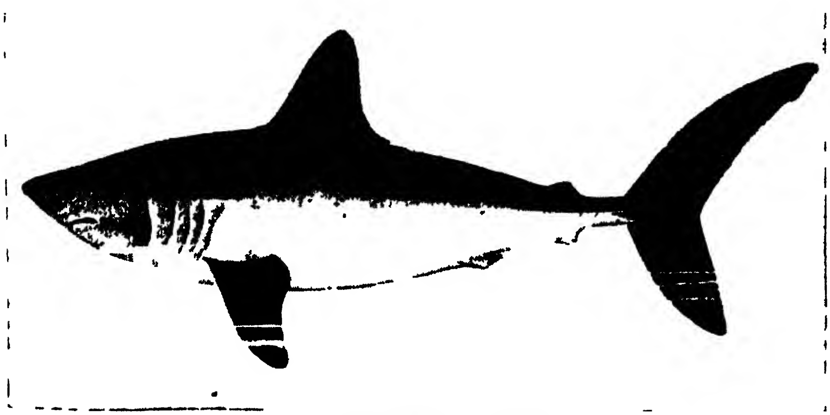
THERE are as good fish in the sea as ever came out of it, but we do not know quite how "good" they may be. The deep has not yielded up all its secrets. We are still making discoveries. We know pretty well all that is to be learned of the commoner facts as to the surface-keeping fish; we know approximately the story of the fish that keep the middle depths; and we have worked out the life-histories of those that hug the floor of the sea within a reasonable distance of shore. But we have not brought a searchlight to bear upon the life of the uttermost deeps. Many strange fish have been hauled from the abyss, hauled with their scales at right angles, and eyes bursting from their sockets, at the withdrawal of the water-pressure to which they are accustomed. As these eerie creatures can be referred to known existing species, we are apt to say that we have the key to the life of all that is in the sea. But we have not.

No contrivance has yet been invented big enough to grapple the larger forms of life that may be there. We know that fish flourish three miles deep in the ocean; it is impossible to believe that the few dredges and drag-nets let down by investigators of the pelagic deeps have brought to light examples of all the life that is there. Still, admitting this, the men who do their business in the great waters have built up through the ages a story of incomparable fascination of the mysteries and wonders of the deep, where all life originated. It is something that we have been able to classify the known denizens of the deep into between nine thousand and ten thousand living species, and to discover and describe upwards of a thousand forms of fossils that once undoubtedly were distinct species of fish.

How the fishes became the first of vertebrates, and how from these the higher forms of life arose, is too wide and technical a subject for treatment here. We can pretend to no more than a fleeting glimpse at some species as they are today. It is suggestive enough that we find sea-animals which we call fish in the lampreys and hag-fish, which are not fish at all that have never attained the backbone the larval fish sets out apparently to acquire; that we have lung-fishes suggesting the rise of the amphibian; that we have fish which give birth to living young; that some, like the stickleback, make nests; that others, like the paradise-fish and the pipe-fish, incubate their eggs within, or attached to, their own bodies; that fishes exist which survive the temporary drying up of their habitat, and that others bear without inconvenience being frozen solid, in the adult stage; that some boldly leave the water, and travel on their fins over dry land; that, while the deepest abyss is the home of specialised forms, others can at will rise into the air and achieve flight on wing like fins, challenging comparison with the aerial feats of many of the so-called flying mammals or reptiles; and that in the warm waters of the tropics we have fishes whose gorgeous colouring favourably sustains comparison with that of the loveliest butterfly of the paradise of butterflies.

Fish-life is favourable to an enormous multiplication of species and individuals. Water covers three-quarters of the earth, and in it life teems in incredible hosts. The existence of such a teeming life demands the maintenance of huge supplies, and Nature has a way of meeting her liability. If a species is to continue, it must, where its individual members are exposed to peril, be exceedingly numerous,

and we find in fish-life a fecundity which has no equal in any other phase of the animal kingdom. Here are some of Dr. Wemyss Fulton's figures bearing on this point, showing the number of eggs laid by fishes: Ling (54 lb. weight), 28,361,000; turbot (17¾ lb. weight), 9,161,000; cod (21½ lb. weight), 6,652,000; herring (11½ inches long), 47,000. All these eggs, fertilised by the male as they are deposited, might produce the perfect fish, but we know, of course, that no such thing happens. From its own bodily organism every maternal ling or cod or herring is a food-provider for hosts of other forms of fish-life. The egg from which the adult fish ultimately results is the exception. Were it otherwise, the seas, in all their amplitude, would not long remain fluid. Were they left to increase unchecked, we should walk dryshod from here to America on the bodies of ling and cod.



THE PORBEAGLE SHARK

The product of these fruitful fish serve, either as ova or larvæ, as food for other fishes. But, of course, ova and fry are but a small part of the food supply of the whole upon which the families of the ocean depend. The unending quest of food in the sea has called into existence as many remarkable expedients as are to be found throughout animal life ashore. We trace curious results from this cause. Some fish cannot live in fresh water, others are intolerant of salt water. Further groups flourish in a mixed medium, the brackish waters of estuaries; while others, such as the conformable stickleback, are equally at home in fresh water or salt, passing with indifference from the one to the other. As against this we find oceanic fish unable to suffer any change in the salinity of their habitat, and fresh-water fish which perish if removed even from one stream to another, where the conditions, to human senses, are practically identical. You may safely bring a golden carp from China frozen in a block of ice, and thaw it out in the hot water of a stovehouse of tropical plants, and it will take no harm, yet fish by the hundredweight perished in the Thames last year, when, following the drought, there came a rush of cold flood-water through the river locks around which they were congregated.

Correlated with this variability of habit are differences as striking in the matter of feeding. We have mud feeders, we have vegetable feeders, we have the omnivorous and the preponderating carnivorous feeders; we have fish which are parasitic upon low forms of life, such as find food and abode within the sea-cucumber, while others, eclipsing the horror of the grampus, which rives the tongue from the living whale, burrow into the flesh, and devour the living substance of their host. There is, on the whole, little to inspire respect for unrestrained Nature as her ways are revealed in the struggle of the fish for their daily bread, so to speak; everywhere the dominant rule is, "eat or be eaten"—or both. The vegetable feeders are food for the smaller carnivorous fish, and these, in turn, constitute the diet of the larger, which themselves are sacrificed to the appetite of those that are larger still.

It is with the great warriors of the deep, and some of their allies, and some that are not their allies, that we are here concerned. First come the sharks, which constitute an ancient and remarkable group. Many of them are egg-layers, the ova being produced in capsules to which long tendrils are attached, by means of which the capsule becomes anchored to seaweed or other place of safety. But other sharks produce their young alive, and in two there is a suggestion of that internal connection between mother and offspring characteristic of the mammal. Needless to say, all the members of the shark tribe

are carnivorous; and although the giants of the order, the whale-shark and the basking shark, like the baleen whale, are content with the smallest of prey as a diet, we have, at the other extreme, in the white shark, a fish which snaps up a man with the same relish and avidity that an adult crocodile displays. The porbeagle shark, dread enemy of fishermen and bathers alike around our coasts, has also to be numbered with the enemies of those that go down to the sea, but not in ships.

After the many well-authenticated instances of the man-eating proclivities of sharks, it is strange to find certain writers still questioning the indubitable ferocity of these creatures. In some quarters it has even been questioned whether the larger sharks really visit British waters. Sharks, it is argued, are natives of warm seas. Exactly! And where seas are warm, there sharks go, retreating as the temperature of the water chills. But if any legitimate doubt remained, it was set at rest in September of the present year, when four white sharks, each measuring between twenty and thirty feet in length, were destroyed off Penzance, where they had caused a complete cessation of the pilchard-fishing, endangering the lives of fishermen, and biting or breaking their nets to pieces. It happened that an officer on board the vessel sent against the pests recognised the sharks as belonging to the same species as one which he had helped to catch off the West Coast of Africa, in the belly of which was found the hand of a woman, with two rings on the fingers. The question of the habits of the shark was discussed some time ago by an expert in the "Times," and the conclusion to which his investigations led him was that many of the mysterious cases of drowning of powerful swimmers off our coasts are due to the victims having been seized, not by cramp, but by sharks. A man who is quite at home in the sea is observed suddenly to fling up his arms, and his body never reappears. We hear no more of the unfortunate until application is made in the Probate Court for leave to presume his death. "Shark" is the verdict of the expert in question.

The only foundation for the belief that sharks do not attack human beings is the known fact that these creatures are great cowards, and can be frightened off by a struggling man, so long as he has vigour enough to maintain his exertions and outcries. We say "coward" in a case of this sort; we say "cautious" or "cunning" when the shark is carefully investigating our bait with the circumspection of a sophisticated trout. This is the sort of thing that happens: A man bathing at a distance of 400 yards from the shore between Hastings and Fairlight felt something in contact with his left leg. He struck out wildly, and immediately his left arm rubbed against, or was rubbed by, a huge fish. At this, he shouted, and swam with all his might, and two or three times the fish rubbed and scraped against him. The swimmer managed to attract the attention of two men in a boat, by whom he was rescued. As he was pulled into the boat, a large blue or porbeagle shark rose to the surface of the water, and rapidly circled about the little craft. The fish had pursued its normal tactics. It did not, as some of us would expect, immediately seize the swimmer; it behaved towards him as it would behave towards any kind of bait. Sharks always swim round the intended victim half a dozen times or so, nosing, rubbing, and pressing against him. Then, if all seems well,


THE BLUE SHARK

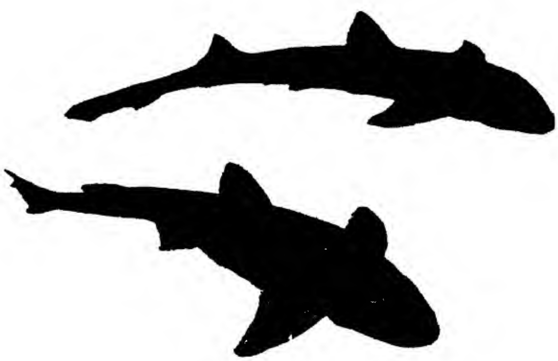
they lay hold with their teeth, when a man's leg snaps like a carrot, and a child or a woman may be bitten in two.

There is no escape from a shark which cannot be frightened. It has been computed that a full-sized shark, in moving

through the water at top speed, exerts a horse-power equal to that of a fair-sized steam-tug; and though it cannot match the sixty or seventy miles an hour at which the United States Fish Commission declares

THE ELFIN SHARK

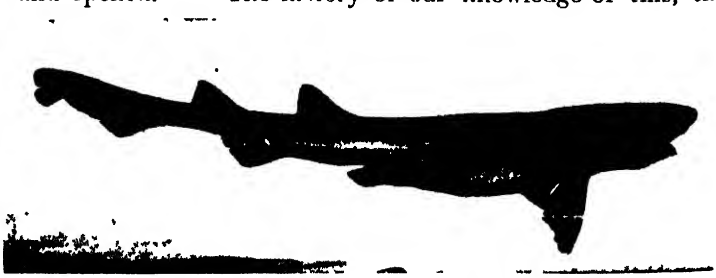
the mackerel to swim, it is possibly, next to that handsome express, the fastest thing in the waters. Expending such a tremendous amount of energy, it needs constant supplies of fuel, and it takes anything that comes its way, from seaman to sea-mouse, making light of such unconsidered trifles as the sack of coke which Mr. Bullen saw one swallow. There must have been a very anxious rush for food on the part of another shark with which Mr. Bullen made acquaintance. This, measuring fifteen feet in length and nine in girth, had swum unscathed down the throat of a huge sperm whale, and was found intact in the stomach of the mammal when the latter was caught and opened.



MALE AND FEMALE SMOOTH-HOUNDS

Sharks are an ancient type; and although, owing to the cartilaginous nature of the skeleton, we find few remains beyond teeth, we know even from the latter that there were giants in the old-time seas. Marine as a whole, they are exceptions to the rule that true pelagic fish cannot live in fresh water. One species (Carcharias gangeticus), common in the Ganges and Tigris, ascends the latter a distance of 350 miles from the sea. This species is represented in the Viti Levu Lake, in Fiji, which is cut off from the seas by a cataract. In Lake Nicaragua, too, in permanently fresh water, we find sharks. Sir Montagu Gerard tells of a singular colony in Egypt. Captain Sherard Osborn, R.N., pointed out to him a spot on the African side "where in previous years, when making a chart of the coast, they found an inland lake of volcanic origin, cut off from the sea by a wide sandbank. They dragged their boat across to explore this, and found it was teeming with sharks, which they supposed had entered at an unusually high tide. The sharks followed them, and even snapped at their oars, being apparently starving."

Naturally, it is not among creatures of circumscribed surroundings such as the examples here mentioned that rivals to the old-time giants are found. But existing species do rival the dimensions of some of the sharks that were. The inoffensive basking shark, commonly hunted for the sake of its oil, is generally regarded as the largest member of the order. But we know now that the estimate is wrong. The length of a full-grown basking shark is stated to be 30 feet but the whale-shark attains twice that size. The history of our knowledge of this, the



THE SPOTTED DOG-FISH

second largest animal in the entire world, should teach humility to those who dogmatise on slender data.

The first specimen was obtained in Table Bay, nine years before Queen Victoria

ascended the throne. Forty years elapsed before another was recognised, and another ten before a third was seen. Yet it is now known that the whale-shark has a wide distribution within the tropics; it has been captured off the coasts of South Africa, Peru, Ceylon, and in the Seychelles. Fishes 60 feet in length and of enormous bulk can thus swim the seas unnoted or unseen. It is singular that the whale-shark, like the basker, should be absolutely inoffensive unless attacked, and that its diet should consist of small gregarious fish and small invertebrates. As a fact, the dreaded white shark is larger than the basking species, the records showing that a length of 40 feet is attained by the adult man-eater. The monster teeth of extinct examples of the species which are commonly found declare, however, that the latter-day tiger of the deeps is but a dwarf compared with the monsters that once roamed the waters. But the bulk of the survivor—though not so deep as a well, though as wide as a door—will serve; and there is probably no creature more admirably adapted to life in the seas than this most generalised of sharks.

Besides the groups already enumerated, we have several sharks distinguished by special adaptations. The Port Jackson shark, which ranges the seas of Japan, Amboyna, Australia, the Galapagos Islands, and California, is a notable example. Here the mouth is not placed on the under side of the body, but is practically terminal, and possesses an armoury of teeth of which the foremost are adapted for gripping and snatching, and the hinder for pulverising the hard shells of crustaceans upon which in the main it subsists. These latter teeth are aptly described as resembling pavements, and no better crushing instrument exists in Nature. Another remarkable family comprises the four species of comb-toothed sharks with the fringe-gilled shark, Chlamydoselachus anguineus. In all other sharks the gill-clefts number but five, but in this family they are six or seven, and the teeth, of which several series are in use at the same time, have sharply pointed cusps, the principal ones resting upon a long base, all inclining in one direction, decreasing in size from front to back.

AN ANGEL-FISH OF 200 POUNDS

The dog-fish, with which parts of our coasts are infested, are really small sharks. The true dog-fishes, of which there are a score of species, are represented in British waters by the lesser and larger spotted dog-fish. We have, further, the spiny dog-fish, also called piked dog-fish, from the spine with which the dorsal fin is armed, and with which a dangerous wound is inflicted. The females of this latter genus hatch their eggs within the body. A related fish is the smooth-hound, which fishermen anathematise when pilchards and herrings are for the harvesting. The smooth-hound gives birth to about a dozen living young at a birth, and in this shark we find the true placental association between the organism of parent and offspring. Our numerous dog-fish, viewed as profitless except for the shagreen which their skins produce, have long been a menace to our fisheries. They take the bait, they devour the fish, they cut the lines, and destroy the nets. All this they were left to do unchallenged, because through a bad name they were regarded as useless. But the economists of the seas are changing all that. Conferring a fresh name, they sell its flesh as food, and excellent flesh it is. They can make use of the numerous eggs as food to the epicure who loves a fish-flavour

to his egg; they extract oil declared by health authorities to be, in its refined state, as valuable as cod-liver oil; and, where the catch is abundant, as in Canada, for example, an industry is springing up for converting the flesh into food for tinning, or into a species of guano for fertilising the land. We shall not again, or we should not, hear of the dog-fish as an enemy, but as a considerable adjunct to the revenue of our valiant harvesters of the sea.

Of other sharks we must notice the blade-snouted variety from Japan, otherwise known as the elfin-shark, from its extraordinary shaped head, which is characterised by the presence of a long, flexible, horizontal blade projecting from the back of the skull in front of the muzzle so as to leave both jaws free. What purpose this singular development serves we do not at present know. The fox-shark, or thresher, is at once identified by the inordinate length of the upper lobe of the tail fin, which suggests the ample brush of a fox. It is one of the smaller members of the family, but is a terrible foe to such small fish as mackerel and herring. In the stomach of a single specimen nineteen mackerel and two herrings have been found. The name "thresher" arises from the action of the shark in beating the water with its long tail in order to frighten into a compact mass the scattered fish upon which it intends to prey.


THE HARRIOTTA

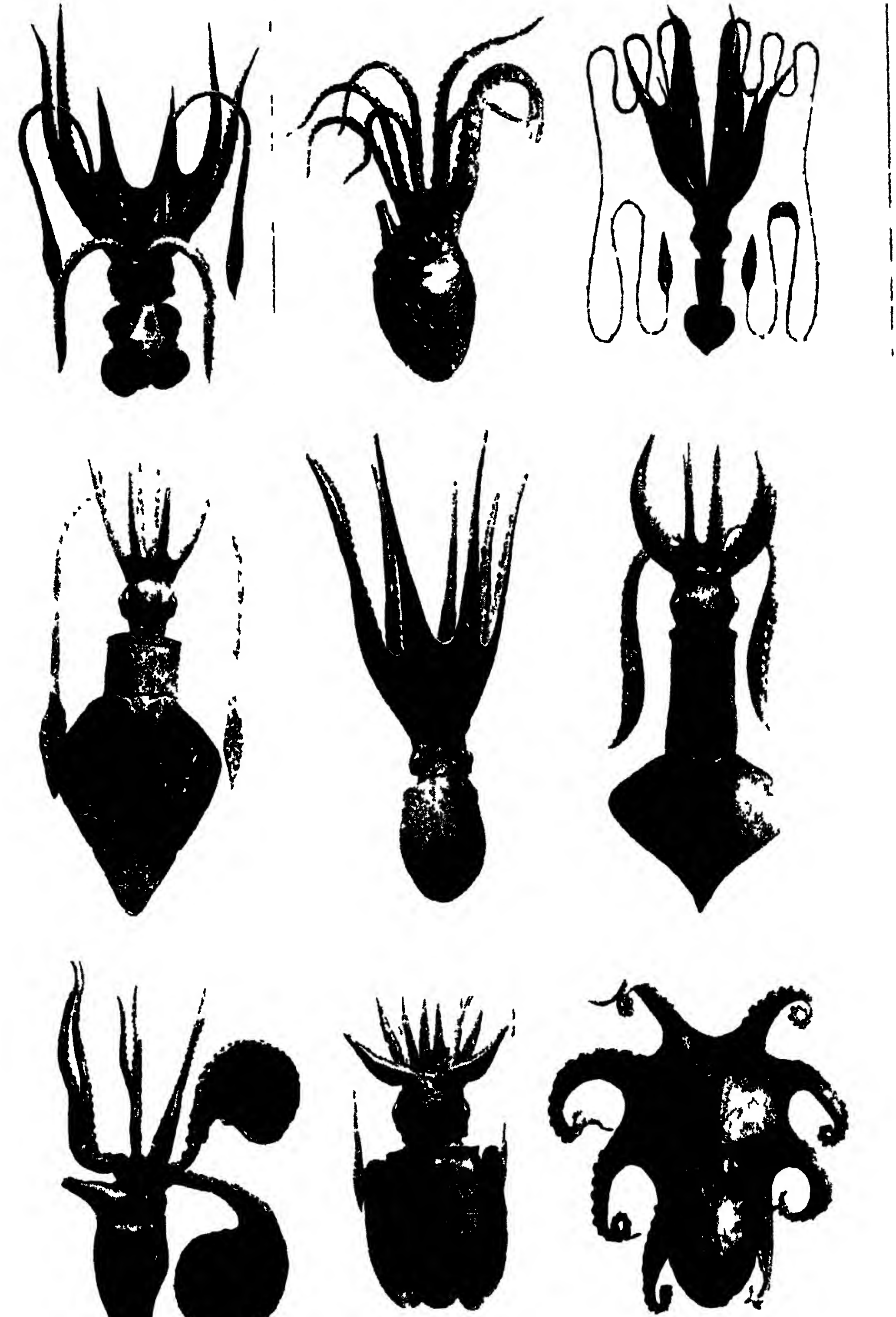
The hammer-heads, again, are singular examples of specialisation to ends which we do not understand. The head is extended on each side into a process bearing the eye; and unless a wider field of vision be by this means commanded, it is impossible to suggest any advantage from the specialisation. Hammer-heads attain a length of fifteen feet, and in Indian waters are greatly feared. As Greenland has given its name to a famous whale, so it perpetuates its title in that of the redoubtable Greenland shark. This animal, while much smaller than the white shark, is still a terrible foe, and is a relentless enemy of the great "right," baleen whale, from which it rips the living flesh, and so devours practically alive. Other sharks are the zebra, the topes, and the spiny. The latter has not discarded the armour of spiny tubercules which remind us of the defences of old-time members of the order. As this shark frequents the lower depths of ocean, where fish are possessed of enormous teeth, it may be that the armour still serves a useful end; but the greatest and most powerful sharks have all laid aside their mail, and depend upon speed and agility for livelihood and defence.

We pass next to the connecting link between the sharks and the rays. This we find in the curious angel-fish or monk-fish, a large flat fish, reaching a length of five feet or more. It is remarkable for the great extension of its pectoral fins, which have suggested the wings of a highly unprepossessing angel. Cosmopolitan in distribution, it is common off British coasts, where every now and again examples of its voracity are forthcoming. Thus, of two captured at Scarborough, one was found to have swallowed a lady's hat, and the other a two-pound tin of mustard; while a third, landed at Falmouth, had posed as a gentleman of easy circumstances, though unconcernedly accommodating in its interior a piece of elm, eighteen inches long and twelve inches broad, and well studded with massive nails.

Next to these we have the saw-fishes, the skates and rays coming later. Of saw-fishes we have two distinct families, one, popularly known as the side-gilled saw-fish, possessing lateral gills, resembling those of the shark, the other, or true saw-fish, having the gills on the under surface of the body, as in the rays. The first named is the smaller fish, the true saw-fish of the tropical seas measuring, in the adult stage, fully 20 feet in length. These are much-dreaded creatures, for with a weapon fully six feet long, and a foot broad at the base, they are able to deliver terrific sidelong blows which suffice, it is reported from Indian estuaries, to cut a man completely in halves. Flesh of the victim is ripped off by the saw, and the smaller detached fragments are eaten. In attacking lesser fish this monster swings his deadly weapon from side to side, disabling many of the shoal, while its method against a whale is to dive beneath the leviathan and thrust its terrible weapon into the soft, blubber-covered body, and to saw into its vitals.

The saw-fish, which is a highly specialised form of shark, is not to be confounded with the sword-fish, which belongs to a quite

MOLLUSCS STRANGE IN FORM AND HABIT



TYPICAL EXAMPLES OF THE CLASS TO WHICH SQUIDS, ARGONAUTS, AND OCTOPI BELONG

different order. Which of the two is the more to be dreaded is open to doubt, for the attack of either, if pressed home, is fatal to human life. The sword of the sword-fish is a prolongation of certain bones of the upper part of the head, and in large specimens is over a yard in length, while the body of the brute may extend a further ten or twelve feet. The whole framework of the sword-fish is built for impetuous charging. The fish makes a fierce rush at its prey, and transfixes it with its terrible weapon. Whales, as well as lesser creatures, fall victims to it, while bathers have more than once been fatally stabbed by the invincible sword. Well, not "invincible." The stout timbers of ships have again and again been penetrated by the sword, but have held the weapon which assailed them, and the sword-fish has gone weaponless away. Sailors whose vessels have been attacked in this way have fancied that the ship has struck a rock. Fragments of many a ship's timbers are preserved in museums with the sword still embedded, one in the British Museum showing stout oak penetrated to a depth of 22 inches.

Returning to our original group, we note the skates and rays, which are related to the sharks. Unlike the latter, the rays prefer coastal waters; and though eagle-rays are sometimes found in the open sea, it is surmised that such are within easy approach of shoal water. For the most part, they pass their lives at the bottom of the water, where their colour approximates so nearly to their muddy environment that fish unwarily approach, to be suddenly encircled by the flexible tail and whipped under the ray's body, or to be pounced upon by the ray entire, which latter feat the ray performs by a quick, gliding movement, giving it a position in which it can encircle its prey with its voluminous pectoral fins.

British waters support ten species of rays or skates, of which the thornback is perhaps the commonest. A rare visitor to our coast may be an eagle-ray or whip-ray so called from the long, whip-like tail, which armed with a barbed spine, is a formidable implement, as every fisherman who has been lacerated by its vigorous lashings is aware. Some of these rays in the warmer waters of their habitat have a measurement of 15 feet, and weigh upwards of 800 lb. A still larger ray is found in Indian waters, measuring fully 18 feet across, and endowed with a mouth like a cavern.

The most interesting members of the ray tribe are the electric or sting rays. Like the so-called electric eels, which are in reality not eels at all, but relatives of the cat-fish and the carp, the electric rays have the power of emitting electric shocks, a power derived from a series of vertical hexagonal prisms, situated on each side of the front of the disc, between the head and the pectoral fins. For long it was doubted whether the effects were electrically produced, but it is now well established that such is the case. "Needles have been magnetised by it, just as if the shock had been that of a galvanic battery; the electrometer shows decided proof of the nature of the current sent through it, and even the electric spark has been obtained from the torpedo—small, it is true, but recognisably apparent." This remarkable power is employed to benumb fishes which the ray has not speed enough otherwise to catch; and the force is sufficient, even in a ray measuring only from two to three feet across, to stun a man.

A CUTTLE-FISH WITH ITS FEELERS EXTENDED IN SEARCH OF PREY

The last fish which bears distinct traces of its rise from the same stock as the sharks is the chimera, or "king of the herrings," restricted to three genera. It derives its popular name from the zeal with which it pursues and devours herrings, albeit it does not restrict itself to these fish, but takes any not too large and not too swift. The southern example, from a curious cartilaginous prominence, ending in a flap of skin on the snout, is known as the elephant-fish

while the third genus, Harriotta, is distinguished by the prolongation of the snout.

We touch another form of sea-warrior, not fish in the scientific sense of the term, in the cephalopada—the squids, octupuses, and cuttle-fish—but they are, as to the first and second, at all events, as much to be dreaded as any other form of life in the sea. Here specialisation has reached a very high stage, for we have colossal creatures that have developed and improved a form of locomotion found elsewhere only in very low forms of life. As the water is expelled from the gills, the creature darts backwards with lightning-like rapidity, and, further to facilitate escape, discharges a cloud of inky fluid which, from the time that man first began to capture cephalopods, has served as the " sepia " of the colourman.

The squids are cigar-shaped in body, and have enormous tentacles ; the octupuses have the body seated, as it were, more on top of the arms. The first-named, however, are unique in possession of enormously elongated tentacles, the waving of which, in combat with other giants of the deep, has given rise to many a story of the sea-serpent. Observations have shown that these tentacles may reach a length of 30 feet, with vast girth and power. The tentacles are armed with sucker discs as big as saucers, and around the edge of each rises a series of claws like those of a tiger. The talons grip the flesh of the victim ; the disc, by a sucking action, holds it fast, and the vast, vine-like arms hold and draw the victim to the frightful rasping beak of the squid, to be devoured. Mr. Bullen has described a combat between a squid and a giant sperm whale, in which the whale, placid in the grip of the squid, was simply eating its captor. Carefully estimating the size of the squid's body, Mr. Bullen compared it to " one of our ship's pipes, which contained 350 gallons."

In another place he tells of cutting open a whale which contained undigested fragments of the arms of a squid. One such fragment was eight feet long and eight feet high. The octupuses are smaller, especially in point of tentacles, and, haunting rocky depths rather than the open sea, are more to be feared by man than the ocean-keeping giant squid. The cuttle-fish, which in habits and structure approximate more to the octopus, are great enemies of fishermen, and were so numerous a few years ago in British waters as to make the landing of nets a matter of extreme difficulty. Of such are the living terrors of the deep ; and of all the forms, hideous and repulsive and deadly, perhaps there is none quite matching the horror and loathsomeness of this " insatiable nightmare of the sea."

AN OCTOPUS ATTACKING A LARGE CRAB

LOVE "OFT TO AGONY DISTRESSED"

THE LAST WATCH OF HERO FOR HER LOVER, LEANDER—BY LORD LEIGHTON

THE ELEMENTS OF EMOTION

An Analysis of Man's Principal Primary Instincts, and Their Expression as Emotions

THE COMING OF FEAR, WONDER, AND LOVE

THANKS to the labours of those who have devoted themselves to the great borderland between biology and psychology, we have been able to define the instincts in man, to see them in their due importance, and to realise that every instinctive act is the outward and visible sign of an inward and psychical state which we call an emotion. This is great gain. When we realise, further, that these pairs of instincts and emotions are what move us that they are the veritable motors of man, the springs of our being, the pulse of the machine, and that the balance between them, in any personality, makes the essential difference between such Generals as a Napoleon Buonaparte or a William Booth, between a Nero or a Marcus Aurelius—we shall agree that no study of these fundamental architects of human history and destiny can be too sincere and detailed.

In this place, of course, our account must be summary, but, at any rate, the dominant emotions and instincts can be dealt with; and the reader who wishes to go further will consult Dr. McDougall's "Social Psychology," in which, for the first time, this question is seen and stated in its proper proportions. Hence we can at least observe the main features of such emotions as wonder, anger, pity, fear, tenderness, which we consider ourselves entitled to call primary. Let that last word be noted. In chemistry we are all agreed that things must be analysed before we can understand them. We must get down to elements or primary things. If water is an element, well and good, but, if not, it is an epoch-making step to resolve the molecule of water into its constituent atoms of oxygen and hydrogen. So with the mind.

For ordinary purposes, just as water is water and that is good enough, we may talk of love, of conscientiousness, of patriotism, or other states of mind, as if they were primary, elementary states of mind. But directly we want real knowledge, to distinguish the kinds of love and conscientiousness and patriotism, the real and the false, the selfish and the unselfish, and so on, it is necessary to effect a sort of chemical analysis of the mind, so as to get at its real, primary elements. This is one of the great tasks of psychology at the present day, not least because it is directly complementary to the work of the new science of genetics, which also studies the elements of the human constitution and the manner of their hereditary transmission. Both the genetic student and the psychologist fail and find chaos when they take complex things for simple, and both find order and reason when they succeed in this fundamental task of analysis.

We duly note and accept, therefore, the term *primary emotions*, and sharply distinguish them from such things as sentiments, dispositions, creeds, and what not, which are complex products of simpler things -always, no doubt, with primary emotions as their root. And if we can credit invisible things with reality, as many folk cannot, we shall try to realise that these primary emotions, and the instincts which are their outward and effective aspects, are as definitely the fundamentals of the mind as, say, the skeleton, the nervous system, the lungs, the circulation, are the fundamentals of our bodily organisation.

It was observed that the true emotions and their instincts are common, in large degree, to all individuals of any given species, and that they make for life. They have what Professor Lloyd Morgan has happily taught us to call "survival-value." That is why they are there, why evolution has framed them, and why they are and must ever be important, even in so

sophisticated and almost more-than-natural a species as man. Nowhere is this characteristic better illustrated than in the *instinct of flight and the emotion of fear.* Low down in the animal scale, this instinct may not be necessary, but anywhere in the neighbourhood of our own exalted species we find it very marked and very important. We may suppose that, say, the tiger or the lion knows no fear, but that is untrue even of the adult, and more so of the young. The young of lion or man that knew no fear would never reach adult life; such a species would have no history and leave no trace.

The Association of Instinct and Emotion as Seen in Flight and Fear

The association of instinct and emotion is here unmistakable. One does not need to be a psychologist to know that flight and fear have something to do with each other. Their strength varies in different species, though any individual of almost any species will run for its life when it must. As a general rule the manifestations are much stronger when they are most necessary, as in children and in women, in our own species. The various physiological facts of fear and of its extreme and dangerous form, which we call terror, are familiar enough. What we know less well, perhaps, is the purpose of them in their normal form.

In instantly paralysing terror there is only frustration of the natural purpose, but we may probably be convinced that the tense limbs, the deep respirations, the strongly and quickly beating heart of fear, are for the vital purpose of effective flight. And we shall be wise, henceforward, in noting the physiological and instinctive phenomena associated with any emotion, to search for an effective use and purpose in them, as in this case. For a noble and touching account of what fear and flight really mean, no one could do better than read Wordsworth's poem, "Hart Leap Well," which describes the overwhelming influence of this dominant emotion upon the behaviour of a pursued creature.

Instinctive Cries and Alarms and Their Surviving Effects on Men

The human being, in the young state, is frightened by animals very often. Even the grown man may have a little thrill of fear and a tendency to run when a dog barks at his heels. He is frightened, too, by noises, especially of low pitch, suggesting a hereditary alarm at the voice of the large carnivores, and often by high winds. The reactions are very decided. The frightened child, or man, is apt to produce an instinctive cry. The "survival-value" of such a cry is evident, for it brings the mother to the rescue. As for the tendency to paralysis which extreme fear may induce—a tendency which may be disastrous if it supervene too soon, for then we do not escape, but are "rooted to the spot" it is not quite morbid, after all, for it may be a natural aid to the motionless concealment which is the primitive object of flight. Even the adult may hide his or her head under the bedclothes when alarmed at night. But, whether in the child or the adult, the unknown, as such, is a great agent of fear. Hence our fear of the "supernatural," the mysterious, the inexplicable, especially if it be on a large scale. Thus fear is a primary constituent of those highly complex emotions which we call awe and reverence, and plays a part in all religions. As Dr. McDougall says: "It is thus the great inhibitor of action, both present action and future action, and becomes in primitive human societies the great agent of social discipline through which men are led to control of the egoistic impulses."

Is Society Held Together by Fear of the Policeman and the Hereafter?

Probably the word "primitive" is superfluous. If there were no fear of the policeman or of the hereafter, it is doubtful whether civilised society would last for one day. Alike for societies as for individuals, it is probably true that, as Burke said—thereby crystallising the biology of the subject—"Fear is the mother of safety." As for fear of the unknown as an element in religion, the representatives of religion have always known this well. In all ages they have used mystery as their great instrument. Thus, the age-long conflict between the representatives of religion and those of science or knowledge is explained; and the practical arguments in favour of fear of the unknown as necessary for society are forcibly stated in M. Brieux' play "La Foi," recently played in London by Sir Herbert Tree, under the title of "False Gods."

On the other hand, the reply of science to those who, insisting on the valuable sanctity of the unknown, would not permit it to dissect the human body, or to study life, or the causes of thunder and lightning, is Herbert Spencer's—that, the larger the sphere of the known, the larger is its area of contact with the unknown. Only perhaps the representatives of established religion are not sure that the unknown of science will coincide with and corroborate the unknown upon which they rely.

In some ways the instinct and emotion we have discussed are supremely important. So much cannot be said, perhaps, for *the instinct of repulsion and the emotion of disgust*, though our modern knowledge of the nature of disease, and its origin largely in putrefying and disgusting material, may suggest that repulsion and disgust are as necessary to our lives as anything else. Disgust is clearly allied to fear, because they both issue in aversion, and often go hand in hand. The notable difference is that, while fear induces flight, disgust induces us to deal with the offensive thing, as when we spit out a mouthful from a rotten egg, with a face expressing the emotion of disgust.

Why do We Shrink from Snakes with an Instinctive Disgust?

Some historical interest attaches to the repulsion and disgust, accompanied by a "creepy" shudder, that are excited by slimy, cold things, such as snakes. There can be little doubt that snakes were the chief enemies of our remote, tree-dwelling ancestors, and that when "Probably Arboreal" came to earth it was snakes that he and his young had, above all, to fear. It is notable that we apply this instinct and emotion in the moral sphere. Thus, we say of a man that his character has an evil odour, that it makes us sick to think of him, that he is rotten to the core, and we experience and display the phenomena of disgust at the thought of him, though he may be the best-groomed and physically most pleasing person in the world.

The instinct of curiosity and the emotion of wonder are not nearly so powerful in the lower animals as in ourselves, whom the apes approach most nearly in this respect.

How Knowledge is Rooted in Curiosity and Wonder

From the point of view of "survival-value," curiosity may seem relatively unimportant, or even inexplicable, for curiosity may lead into danger. But if we consider the conditions of the survival of our own species in the world, in terms of knowledge, and if we ask what induces to the gaining of the knowledge whereby man survives and masters the world, we must reply that it has its root in the instinct of curiosity and its correlative emotion of wonder.

Those men in whom this instinct is strong, and in whom, by practice, it becomes stronger, are the men of science and the thinkers. In them, as in a Darwin or a Newton, it becomes the great motor of intellectual effort; and most of the greatest and most disinterested achievements of the human mind have this as an essential part, at least, of their source. It is thus one of the principal roots both of science and religion; and we must reasonably connect the infant which puts any strange object to its sensitive lips, so as to learn about it, and which reaches out its hand to anything bright and unknown, with the astronomer who reaches out, with the same motor behind him, for an unknown star or planet. It is a fact of this instinct that, if neglected or overwhelmed by others, it tends to atrophy. Many a bright and intelligent child, eager to learn, full of wonder and interest, turns into a mature person who cares for none of these things.

The word "wonder" means more in ordinary speech than here. When Wordsworth say that "We live by admiration, hope, and love," he there means by "admiration" "wonder" in the ordinary sense—a complex emotion which contains pure curiosity, but something more as well. Here is one instance of the importance of analysing our terms and ideas, so as to distinguish between what chemists would call compounds and elements; and, as in the case of the chemist, existing language soon becomes inadequate for the distinctions we begin to recognise.

How the Instinct of Pugnacity and Emotion of Anger Come Into Play

The mixture and alternation of fear and curiosity, the impulse to fly and the impulse to advance and inspect, are often illustrated in ourselves, and in children and in animals, as any observer of a puppy in presence of some small object that emits noises, for instance, may testify. And, at last, a third instinct may be excited with disastrous results to the object in question—namely, *the instinct of pugnacity and the emotion of anger.* Here is an intense and potent instinct, which ranks in those respects with fear. In the female sex generally this instinct is much weaker than in the male sex; and some people are to be found in whom, we might suppose, the instinct does not exist. Even in the gentlest and best-tempered, however, we may at any moment be surprised to find pugnacity and anger aroused in connection with the ill-treatment of the young or helpless. In the case of many animals, the female exhibits no pugnacity or anger except when she has her young, and then in her ferocity she becomes as "the tigress robbed of her whelps."

Apart from this special relation to an instinct which we shall later describe, pugnacity and anger specially show themselves, for most people, in relation to food. As Dr. McDougall says "The most mean-spirited cur will angrily resent any attempt to take away its bone if it is hungry; a healthy infant very early displays anger if its meal is interrupted; and all through life most men find it difficult to suppress irritation on similar occasions."

The New Forms Taken by Pugnacity and Anger in Civilised Man

The "cur" tends to bite; and in Darwin's famous book on "The Expression of the Emotions" we have learnt how the raised upper lip of anger is none other than a preliminary to biting, while the loud voice of anger is shared by many of the lower animals when they are angry, and try to cow their enemy by roaring or bellowing at him. But in the higher types of mankind pugnacity and anger cease to express themselves in this crude fashion. They are decadent and disappearing, we should once have supposed, but this is far from the case. They are there all the time, if we will look for them properly. They are there in the persistent energy, essentially pugnacious, with which a man or woman of this type works towards some end, obstacles notwithstanding; and when this pugnacity and transmuted anger are combined with the parental instinct and its "tender emotion," we find the great reformers of injustice, the great champions of the liberty of oppressed peoples and classes, the Lincolns, Wilberforces, Plimsolls, Barnardos, to name none greater, who honour and exalt mankind.

A famous French student, M. Ribot, was the first to appreciate the importance, as primary emotions, of what he called "negative and positive self-feeling," and what we may here call the *instincts of subjection and self-assertion, and the corresponding emotions of subjection and elation.*

The Part of Self-Assertion and Display in the Drama of the Mind

The names are clumsy, but the facts are very real, and play an immense part in our lives. If we are ever to understand the psychology of character and of will, we must do justice to those instincts and to the emotions which accompany them. There is no doubt about the existence of the instinct of self-display in the lower animals, in children, or in ourselves. The tail of the peacock is an instance of a structure which seems to exist for this display. The horse knows how to display himself, or "show off," with his tail raised, his movements a little exaggerated and "affected" like those of an adolescent youth or girl when he or she is showing off also. This instinct and its emotion are necessary constituents of the sentiment which we call pride.

The instinct of self-display and its accompanying elation can be seen very conspicuously in children, most of whom love showing off and are only too freely encouraged to do so by admiring parents. As for their fine clothes, or riding a bicycle or playing games, they usually find them rather dull if there is no one to look on. What it is nowadays the fashion to call "swank," however it expresses itself, arises from this instinct. The mature man or woman has practised little introspection who supposes that this instinct does not manifest itself, in rather subtler ways throughout the lives of most of us.

The case of clothes is specially interesting to the psychologist, because common thoughtless judgment makes so little discrimination. Two women may both love and wear beautiful clothes, and may both be put down as vain. Yet, in the one case the motive impulse *is* vanity, the desire to show off, the instinct of self-display, with its emotional accompaniment of elation

An Analysis of Feminine Motives in Wearing Fine Clothes

This woman wears her fine clothes in order to be looked at. In the second woman superficially of the same psychical type in this particular, the instinct of self-display may be so weak as to be practically absent. She wears her fine clothes for æsthetic reasons, from a love of beautiful things, and from a liking for what is elegant and clean and delicate. She may intensely dislike being stared at. She wears her beautiful clothes for their beauty, and may not have any vanity of the ordinary kind in her. The first woman may be readily distinguished from the second by the fact that she is a slattern when no one is there, and that the unseen part of her attire is of an entirely different order from that which is seen of men. The second woman becomes more particular about her clothing the more intimate its relation to her person.

The opposite instinct and emotion to the self-display and elation which we have defined are no less real. The emotion of subjection, both in the case of a small dog very often, in the presence of a big one, or in that of a child, safe on its mother's knee,

not afraid, but *bashful* in the presence of a stranger, is definitely and specifically accompanied by a certain course of instinctive behaviour which we can observe from without in such instances. They furnish us with the true instinctive-emotional root of what we call bashfulness or shame, no less than the opposite states furnish us with the root of vanity and "swank."

Students of the mind diseased are only too familiar with combinations of symptoms, described in all the text-books, which receive a deeper interpretation from the foregoing analysis.

Depression and Exaltation as Phases of the Decay of the Mind

There is a malady known as "general paralysis of the insane," a form of poisoning of the brain, presumably with a special action upon the basal ganglia, though this point has scarcely been investigated. Its victim, practically from first to last, is in a state of exaltation. He dies in a state of appalling degradation, mental and bodily, but entire happiness. In the earlier stages especially he boasts of his means, his connections, his accomplishments, fancies himself to be a monarch or a deity, exhibits every sign of elation. The psychological interpretation of all these symptoms would now be that the instinct of self-display is morbidly exaggerated and that the rest follows. The "megalo-mania" *i.e.*, bigness-mania the "delusions of grandeur," the lavish expenditure of imaginary millions upon trifles, all these denote the attempt of the patient's intellect to account for and justify the extraordinary state of elation of which he is the subject.

The opposite picture is no less familiar in asylums for the insane. The victim of melancholia, in contrast with the "exalted" patient, "shrinks from the observation of his fellows, thinks himself a most wretched, useless, sinful creature, and, in many cases, he develops delusions of having performed various unworthy or even criminal actions.

Morbid Exaggeration of the Instinct of Self-Abasement in the Insane

"Many such patients declare they are guilty of the unpardonable sin, although they attach no definite meaning to the phrase—that is to say, the patient's intellect endeavours to justify the persistent emotional state, which has no adequate cause in his relations to his fellow-men." No doubt the true psychological basis of all these symptoms is a morbid exaggeration of the instinct of self-abasement and the emotion of subjection—and the rest follows.

What may be the explanation of this morbid change is a deeper question still, as yet unanswered. But it is an interesting fact that the kind of theory expressed in the ancient name of "melancholia" is beginning to return. That name means "black bile," the theory being that the victim of depression simply suffers from poisoning by means of black bile. The modern view of such melancholia, for instance, as often follows upon influenza, is that it is also toxic.

At present, however, students of insanity have not followed up the psychological clue which seems to be offered here. The cerebral cortex of man is so wonderful, so unparalleled and distinctive of him, that the study of the brain in relation to insanity has almost exclusively concerned itself with the cortex alone. The long-standing error as to the essential nature of insanity has contributed to this mistake. We say a man has "lost his reason," and popular opinion, the law, and, until lately, medical opinion, thought of insanity as a disease of the "mind," meaning thereby the reason or intellect. The patient's belief that he has committed some impossible crime, or that he is a king, is looked upon as the essential fact of his malady; and if we are to look for a physical cause we suppose that it must be in the *cortex cerebri*, the undoubted seat of the intellect.

The Parental Instinct and Emotion of Tenderness in the Mother

But all this is wrong. The patient's delusions, his intellectual symptoms, are entirely secondary, as the account we have given shows. The malady is not disordered reason, but disordered emotion and instinct, with secondary intellectual symptoms, which catch our attention, to the exclusion of essentials. Our search, therefore, in the sphere of morbid anatomy should be directed towards the probable seat of the instincts and emotions —namely, the ancient collections of nerve cells at the base of the brain. In fact, the morbid changes in this part of the brain, except such as are due to accidents like the bursting of a blood-vessel, of no importance in this connection, have never yet been studied. It is not improbable that such study of the basal ganglia, together with the use of chemical tests, would substantially advance our knowledge of certain insane states.

We now come to the seventh and last of the dominant, definite, primary instincts and emotions of man—namely, *the parental instinct and the tender emotion.* Needless to say, a language so rich as English should

provide us with suitable words for the emotion here indicated. Probably "tenderness" is the best, but "love" would be far better, if it were not that the whole vocabulary of psychology is so constantly mishandled and so frequently soiled in ordinary speech that it is almost worse than useless for exact purposes. At any rate, tenderness or tender emotion is what we mean; and it is the affective, psychical aspect of those instinctive actions which we recognise as parental, and which, among ourselves as in the case of most species—there are singular exceptions among the insects—are best displayed in the female sex. Of all aspects of mankind, none has been so extensively worshipped, none so frequently depicted upon canvas, as the activity of this instinct and the expression, in face and hands, of this emotion. Tender emotion is, above all, aroused in the normal human mother by the spectacle of her helpless offspring. Its impulse is to afford physical protection to the child, especially by throwing the arms about it; and this gives the mother delight and satisfaction, even though the child is in no need of protection, and was, in fact, safely snuggled in its cot a moment before. She is also strongly inclined to kiss the child, an act which seems to be closely allied, at least, to the impulse to lick the young which is a marked feature of the parental instinct in many animal mothers.

Tenderness Neglected as a Study by Unemotional Philosophers

This definite parental emotion of what we here call "tenderness" is not to be confounded with sympathy. They are closely allied but they are not the same, as M. Ribot clearly saw. This primary emotion, which is of quite incalculable and unprecedented importance for mankind, has been ignored or misunderstood by psychologists in the past to an extraordinary degree, largely, no doubt, because this emotion is much weaker in men than in women, on the whole, and may, perhaps, be notably so in the type of men who become professional thinkers. Mr. Alexander Sutherland, in his great book on the "Origin and Growth of the Moral Instinct," takes rank as the first effective and devoted student of this subject. No recognised thinker saw its full importance before him, and no one has had any excuse for underrating it since.

Mr. Sutherland showed that the parental instinct, as exhibited by the mother, is common to almost all the higher species of animals. As the forms of animal life ascended from the fish, which may produce a million eggs or more, the number of eggs or young is persistently reduced, while their lowered numbers are compensated for by parental protection. This process culminates, as the present writer showed at the Royal Institution in 1907, in the paradoxical case of man, who has the lowest birth-rate, but alone of all species persistently increases in numbers.

Parental care may begin by being purely mechanical, and always retains a mechanical element, but we soon see modifications of behaviour in its interest and accompanying exhibitions of feeling. Herein we "instinctively" recognise something high, beautiful, almost divine and creative, in the manifestations of life; and thus mother and child worship has been a conspicuous or central element in many of the great religions of mankind.

A Mother's Love the Most Selfless and Exalted of Emotions

We cannot but regard this instinctive act and its emotional correlate as the highest, most selfless, exalted thing we know. It so directly makes for life, and it is so conspicuously opposed, in outcome, to the natural action of the other instincts. Primarily, at least, they are for self, but this is for another.

In its highest form the parental instinct becomes the chief agent in the maintenance of the species. The mother produces only few young, but she devotes herself to them so well, and so long, that most of them reach maturity. As has been well said, "In such species the protection and cherishing of the young is the constant and all-absorbing occupation of the mother, to which she devotes all her energies, and in the course of which she will at any time undergo privation, pain, and death. The instinct becomes more powerful than any other, and can override any other, even fear itself; for it works directly in the service of the species, while the other instincts work primarily in the service of the individual life, for which Nature cares little."

The Shallow Reasoning that Has Pretended to Explain a Father's Love

The parental instinct was no doubt maternal in origin. Among most fathers far back in the line whence we are descended there is nothing of it to be seen. How, then, are we to account for the fact that it occurs also in many men? One explanation is the transference by heredity of a character originally evolved in one sex to the other. Support would be furnished for

such transference by its "survival-value," for the offspring that has two devoted and loving parents is better off than if it had only one. The truly astonishing fact is not that the parental instinct and its tender emotion exist, but that past psychologists have taken such incredibly wrong-headed views of them. Yet, if we do not recognise this primary emotion as "deeply rooted in an ancient instinct of vital importance to the race," we shall have to invent strange explanations for it.

Prof. Bain thought that parental love was generated in the individual by frequent repetition of the intense pleasure of contact with the young; but whence and why this pleasure? Others have absurdly suggested that parental love is due to the parent's expectation of being well cared for by his child when he is old! Prof. Bain deliberately said that parental emotion is selfish, and that we are "looking all the while at our own pleasure and to nothing beyond." Teaching of this kind was inevitable when philosophers started out with the fixed belief that all our actions are essentially egoistic, and that all morality has its root in social convenience or custom or imitation.

How the Common and Uncultured Give Their Lives for the Preservation of Others

No modern student can have anything to say to such a doctrine, of which Dr. McDougall thus disposes: "This doctrine is a gross libel on human nature, which is not so far inferior to animal nature in this respect as Bain's words imply. If Bain, and those who agree with his doctrine, were in the right, everything the cynics have said of human nature would be justified; for from this emotion and its impulse to cherish and protect spring generosity, gratitude, love, pity, true benevolence, and altruistic conduct of every kind; in it they have their main and absolutely essential root, without which they would not be. Any seemingly altruistic action in which it plays no part is but a sham, the issue of cold calculation or of habits formed under the influence of rewards and punishments."

We have already referred to the close organic relation between the tender emotion and the emotion of anger, as in the case of the tigress robbed of her whelps. Here we have the true genesis of one of the great factors of human society. The anger evoked when the parental instinct is outraged is the germ of all that moral indignation upon which the idea of justice is founded. For the survival of mankind it has been necessary that, at any rate in a sufficient number of people, tender emotion and the act of protection shall be evoked not merely by the cry of one's own child, but by the cry of any child—and hence of anyone in the position of a child, anyone who is ill, unhappy, oppressed, weak, in danger. Every day in the year we hear cases where "common," "coarse," "vulgar," "uncultured" men, perhaps hard-drinking and hard-swearing, have given their lives for a child or a friend, in a coal-mine, on the high seas, in the surf, under the influence of this emotion, which is so valuable for mankind, and so markedly superior to all our other attributes, that high and low, civilised and savage, worship it alike.

Sympathy an Infection; and Tenderness an Elementary Instinct

The psychologists of the nineteenth century, denying the existence of parental tenderness as a primary emotion, had to explain it somehow, and sometimes did so, in a not unplausible fashion, by confounding it with sympathy. Sympathy is literally "feeling-with," and it means neither more nor less than that the sympathetic person feels in him or herself the feelings whose exhibition is witnessed in another. The world is full of sensitive, sympathetic people, who dare not even witness the spectacle of pain, are easily disgusted, and must shelter themselves. Their method is to avert the gaze from the painful spectacle and look resolutely elsewhere, like the scribe and the Pharisee who passed by the stricken wayfarer, and who, as Dr. McDougall says, "may well have been exquisitely sensitive souls, who would have fainted away if they had been compelled to gaze upon his wounds." But in the good Samaritan, tender emotion was so powerfully evoked that, however painful or even disgusting the situation, he had to stay there and do something.

Primary Instincts that Exist Independent of Their Racial Purpose

No one will question the real distinction between these two things who has any experience of, for instance, amateur sick-nursing, and the hosts of persons who are so sympathetic and so untender as to be worse than useless. They are the key to such remarks as that of Sir Frederick Treves about the "plague of women" in the South African War. The practical surgeon is like the practical mother, who, when her child cuts its finger, does not faint away to show how sympathetic she is,

but does something on the spot, and faints afterwards, if she has nothing better to do.

There are other primary instincts, notably *the instinct of reproduction and the emotion of sex-feeling*. We do not experience this as an instinct of reproduction, for it has already been shown that, as Prof. James insisted, an instinct exists independently of any recognition of its purpose. We have carefully avoided calling the emotion which accompanies this instinct by the name of "love," which should be reserved for a more complex sentiment. But in our attempt to analyse that sentiment to which the name of "love"--as between the sexes—may rightly be applied, we must note that the reproductive or racial instinct tends to be coupled with and blended in the parental instinct, so that he or she who is the object of our sex-feeling tends also to be an object towards whom we feel tender emotion and the protective, primarily parental instinct. When these are blended, we are much nearer "love"; when there is no addition of the tender emotion to the sex-emotion, then its name, of course, is not love, but lust.

The Curious Case of Creatures that are Gregarious but Unsociable

We must also recognise the *gregarious instinct*, with the unnamed state of emotion which is associated with it, and of which Defoe gives some hint when Robinson Crusoe discovers a footprint which is not his own. In his "Inquiries into Human Faculty," Sir Francis Galton described this instinct in the South African ox, which is miserable unless it is amid its fellows, but then takes no notice of them. Like many men, who hate to be alone, but yet want no companion, they are gregarious, but unsociable. The survival-value of the instinct which prevents an ox from straying away, towards the claws and jaws of a carnivore, is obvious; and a similar argument must once have applied to man in the early days of his history when in their contests with the mammoth and the larger carnivores the primitive peoples proved the strength of combined effort. The necessity for organisation into tribe and clan for purposes of war and associated labour also did much to foster this instinct. The almost universal demand for a crowd, when one wants enjoyment, is based on this instinct.

There is also to be recognised apparently an *instinct of acquisition*, which early leads us to collect things--stamps, coins, or what not—and which either yields to subtler variations of itself in later years, or becomes excessive and mad, as in the miser or the kleptomaniac. No name exists for the state of emotional satisfaction which accompanies the exercise of this instinct, but that there is such a genuine and primitive satisfaction can be seen in the disconsolate child that dries its tears and beams with pleasure when the passengers in the tramcar hand over to it a fistful of disused tickets.

The Fine Instinct that has made Man a Builder not to be Baffled

And, lastly, there is an *instinct of construction*, which gives us a delight in making things. The thing made may be a child's sand-castle, or a "Synthetic Philosophy" to which thirty-six years are devoted; or a vast epic poem, comprising the history of the world, which no one will ever read; or a Forth Bridge, or something cut with a fret-saw; but underlying all such activities we see the working of this constructive instinct, which has, beyond a doubt, played a great part in the development of civilisation, and which probably ought to hold a special place in our esteem, as being distinctively human, a characteristic and invaluable attribute of the "tool-using animal." It is this "architectonic faculty," as some have called it, that impels a man to complete some task he has undertaken, long after the first glow of interest and excitement has cooled. Those who have it not may often start out on enterprises, but they do not "see this thing through."

The Place of Sympathy as a Bond between the Emotions

Finally, let us appreciate the place of sympathy in relation to the emotions. It is not itself an emotion, but it is the process by which one man's emotion infects, or is induced in, another, like the induction of an electric current in the secondary coil of a battery. Fear, curiosity, anger, laughter, melancholy, terror—all of these are capable of being communicated from one person to another by this process we call sympathy. Especially in children do we see this, from the baby which wails when another wails, to the older child which is sad when we are sad and merry when we are merry, and which we love accordingly. We all value this quality in our companions, who "rejoice with them that do rejoice, and weep with them that weep." And now we can clearly understand that it is not an emotion, and what its simple relation to the emotions really is.

DANGER OF EXCESS IN DIET

A Discussion of Modern Theories as to What Should be Eaten, and How it Should be Eaten

THE BEARING OF DIET ON LENGTH OF LIFE

We are all agreed as to the disastrous consequences of an inadequate diet. They show themselves in all degrees, from quickly supervening death to slight degrees of rickets, and loss of general energy. Diet, therefore, is a good thing, and only on careful observation do we realise that we may have too much of a good thing. But today there is a large, influential, and increasing number of persons who say that the diet of the ordinary man, neither a glutton nor an ascetic, is decidedly too much of a good thing, and that nine out of ten people would be fitter and happier on a fraction of their present food. Now, the chances are considerable that not many readers of this chapter require to be warned against the dangers of insufficient food, while hosts, beyond a doubt, may well be warned against the tendency to excess which so often appears with advancing years and extended opportunity.

The real pioneer in this matter was a famous thinker, Dr. George Keith, recently dead, after approaching close to a hundred years. His little book "A Plea for a Simpler Life" was published in 1895, and is more than ever worth reading today, when the mortal disease of luxury threatens many sections of society more closely than ever before. In this justly celebrated book—the sixpenny edition of which should be in everyone's library—Dr. Keith boldly laid down certain propositions which were diametrically opposed to general belief within and without the medical profession. What he there said against drugs and drugging is now echoed by everyone who knows the facts; and his argument against high living, based as it was in his case upon clinical observation and common sense, and dating from about 1860, is now based upon the experience of thousands of persons, and also on a great deal of special experiment, particularly in the United States.

Until very lately, when the nature of disease began to be understood in some degree, medical opinion went through fashionable cycles, just like feminine dress, and with as little reason. In the 'thirties of last century most of the common disorders were ascribed to excess of some kind or other, and treated accordingly. "Depletion was the order of the day." Purgation, bleeding, especially in the spring, cupping, and similar measures were directed against the supposed "plethora," or excess of blood, from which disease was alleged to start. Like other fashions, medical fashion goes to extremes. The extreme in this case often involved bleeding patients to death. Plainly a reaction was due, and a London doctor started it in the 'forties. Some explanation was required for the astonishing reversal of practice, and so the doctors took cover behind that broad bastion for ignorance which we call "heredity." Owing to certain subtle changes, the human body had become modified, so that it was "less able to bear lowering measures than formerly."

It was at this time that Dr. Keith began to lose faith in medical dogmas, first of all in relation to homœopathy. The homœopaths diluted their drugs to such an extent that they practically gave no drugs, while attending to simpler things, like diet and air. They were very often successful. The profession as a whole, of course, hated the heterodoxy of these practitioners, fought them tooth and nail, and learnt nothing from them. Dr. Keith saw that their success was due to their practical abandonment of all drugs, and pondered accordingly. He was called the "starving doctor," and encountered plenty of abuse and opposition, but now we begin to see what a pioneer

he was—one of the few medical philosophers of all time. He saw the meaning of loss of appetite in fever, and the meaning of the desire for water, at a time when every drop of water was withheld from the feverish patient, and when the medical profession defied the indications of appetite in health and in disease even more grossly than the public did and does.

A Nonogenarian Doctor's Advice: Trust to Nature and Avoid Doubtful Remedies

"Better a doubtful remedy than none," said Hippocrates, the "Father of Medicine." "Better no medicine than a doubtful one," was Dr. Keith's emendation, and here are his comments thereon; if they sound rather obvious now, so much the more credit to his influence. "To sum up—the doubtful remedies which, according to the new axiom, are as a rule to be avoided in states of disease are medicines of all kinds, alcoholic stimulants, and food; and Nature's methods, which we advise to be substituted for them, or rather to be allowed full play without them, are rest, not forgetting rest to the stomach; warmth, or, in rare cases, cold; a free supply usually of water and always of fresh air; and sufficient time for the organs to recover their ordinary working powers, and especially for the nervous system to make up its wasted energy. In short, we must fall back on the old and much forgotten *vis medicatrix Naturæ*. I have heard of old men who never had taken medicine, nor consulted a doctor, and who, if they felt unwell, at once stopped all food; if this was not enough, they went to bed, and remained there till they were better. The first rule I have followed for forty years, the last for fifteen, since I have been able to do so, and it has very rarely been necessary; and I do not intend to do anything more in the future. My friends can see the difference in my health, and I feel it."

Dr. Keith's Advocacy of Low Living as a Secret of Health

No doubt these views are rather extreme, and require reservations. One thinks of quinine in malaria, for instance; and the prohibition of "all food" in all forms of illness is scarcely warranted by experience. But during the period of nearly two decades since these words were written, medical science has gone far to ratify them. Now, what applies to disease, which is physiology under abnormal conditions, must surely have its lessons for health, which is physiology under normal conditions. So Dr. Keith went on to apply his views to ordinary life. He declared that "no doubt there are very few healthy people who can afford it who do not usually exceed." So, when he was consulted by men in apparently good health, who complained of being "out of sorts," Dr. Keith advised them to take their food more slowly, and assured them that they would find that less would satisfy them; and this, if carried out, will often enable a man to reduce his food by one-half, and will add very much to his comfort and health.

Dr. Keith pointed also to the influence of high living upon our control of the racial instinct, a matter of great importance for the health and happiness of many men and nearly all youths. He pointed out that high living is fatal to accurate shooting—an assertion which is supported by the subsequent experiments with alcohol in the same respect. Then he points to the cases of such efficient men as Sir Isaac Newton, Napoleon, and the Duke of Wellington, who support his thesis, saying of the last that he, "when engaged in working out some great problem in science or war, took actually no food until the strain was over."

The Battle of the Doctors between a Generous and a Scanty Diet

So much for Dr. Keith, and we note, in leaving him, that he gave no precise rules. There is nothing of his from which we can quote so as to fill a page of this work with precisely defined dietaries, from morning till night, such as will maintain health and postpone senility. The really great thinkers on this subject are never found prescribing after that fashion. Herbert Spencer laid down the rules which should guide us in dealing with the appetite of a child, but he left it to the fashionable physicians of his time to prescribe diets for children, and contradict themselves and each other in doing so. These thinkers see that the real guide is Nature, and that our simple business is to avoid trying to hoodwink and mislead her.

We must now look at the views of a living man who follows Dr. Keith very closely in essential respects. More than ten years have passed since Mr. Horace Fletcher, an American gentleman of leisure well employed, succeeded in arousing the attention of the famous physiologist of Cambridge, the late Sir Michael Foster. Experiments made in Cambridge impressed so many physiologists that the matter was taken up in America, where it was well

known that anything thought noteworthy by Sir Michael Foster would repay investigation. Professor Chittenden, of Yale University, devoted most time to the matter, and is now the leading scientific advocate of the new school of dietetics, to which he has given the name of "economic nutrition." Here we shall certainly not presume to decide a question which is still *sub judice*. In this country, Dr. Robert Hutchison and Sir James Crichton-Browne have vigorously opposed the teaching of Chittenden. Crichton-Browne declares that what he calls "parsimony in nutrition" opens the way to disease, and Dr. Hutchison justly argues that we want to discover not the *minimum* quantity on which a man may be adequately fed, but the *optimum* quantity, which may be a good deal more. Further, students of all these schools have substantially ignored the teaching of modern biology that men are born different, and that the question of the quantity of diet cannot be answered in any terms of universal applicability.

A Contrast Between German Practice in Diet and American Theories

However, Chittenden's work has passed the stage when it can be ignored, or the second stage, which is that of ridicule, and it must be properly examined. It has many followers in America, and several in this country. In Germany, however, official physiology is still content with those exceedingly generous estimates of beef and beer which, in fact, we owe to German physiologists, and have copied into all our text-books. First-hand observation of the nutritive state of the German people, and of their vital statistics, certainly lend no support to their dietetic practice. In Germany meat is slowly beginning to decline in favour, though the amount consumed is still enormous. At a recent International Congress on Hygiene in Berlin, the amount of protein we daily need was discussed, and the opinions in favour of the views of Fletcher and Chittenden were decidedly in the ascendant. One speaker insisted on the possibility of violent athletic exercise on a very low protein diet; and another said that he "had been able to keep his family in health on food which cost him about three-halfpence per head per diem, for years. On this diet his wife could ride her bicycle from eighty to a hundred kilomètres."

This case of Germany is too interesting to be let pass without further comment, though unfortunately we can only speculate. A general rule, true of mankind in all times and places, is that we eat more according as we grow more prosperous; and the greatest excess of all is practised by the newly prosperous. This is true of individuals, or of the groups of individuals who make nations. Germany of today is the most conspicuous example in the world of recent prosperity. Berlin, and the people of Berlin, illustrate the consequences in high degree. Over-eating, under-exercise, plenty of beer, no fresh air on any account – these are, on the whole, characteristic of modern urban Germany.

The Possible Ill Effects on the Birth-Rate of German Over-Feeding

This generous diet is conspicuously without any favourable reflection in the mortality tables; and the medical eye sees malnutrition of the toxic type on every hand, degeneration setting in very soon after adolescence, and destroying the beauty and healthy appearance of both sexes.

If, now, we recall the observations of Dr. Chalmers Watson on the effect of an excessive meat diet, we may well observe, first, that the birth-rate of modern urban Germany is falling with very great speed, which may have a factor in hypernutrition; and second, that the women in the cities are rapidly losing their power to nurse their children. The facts in the last respect are most remarkable and ominous; and while they have national consequences in, for instance, the shockingly high infant mortality of Germany they also suggest an influence of excessive diet upon personal health and development, which seems to be deeply significant. Now let us proceed to a definition of our physiology.

The Danger of Surplus Food Becoming Poisonous and Starting Chronic Disease

The ultimate laws of chemistry assert that we must account for every atom and every molecule of food that enters our mouths. Nothing that we consume is annihilated. We swallow it, and think no more of it, but it has to be accounted for, and one of only two things must happen to it: it must either remain in the body permanently or it must leave the body. Suppose, then, that we take more food than we can use at any given time, the surplus must either be stored up somewhere or it must be disposed of; and this disposal means work, and danger, for the organs of excretion. Danger, we say, because the surplus is liable to become poisonous; and no pathologist now doubts that these food-poisons

are largely responsible for the slow but deadly degeneration of the kidneys which is one of the forms of so-called "chronic Bright's disease."

So it is necessary to find out by experiment, first, how little food the body will thrive upon; and second, what happens to the surplus. The Americans seem to have settled the first point, but Sir James Crichton-Browne is clearly right in observing that it is not enough for man to maintain his weight and physical vigour if, perchance, his vital resistance to disease is being secretly diminished. We must remember this point, for it is just the appreciation of such points that makes the difference between science and popular opinion. The second factor which experiment must ascertain is the fate of the surplus which most of us and, in fact, almost all of us daily consume. For instance, can it be stored up against a day of need?

The Serious Labour of Getting Rid of Superfluous Food

In fine, the theory of Fletcher and Chittenden asserts that the normal food requirement is a mere fraction of what used to be approved; that the surplus can be stored up against a day of need only to a small extent, and not at all in the case of the most important food, which is protein; and that the business of disposing of the surplus is a serious one, involving labour on the part of many vital organs, and in the long run nothing less than chronic food-poisoning, for which we pay in the form of degeneration of the blood-vessels, kidneys, and other organs. These are the very degenerations which pathology, knowing nothing about them except that they are not commonly found in the young, and tend to become worse with age, has put down as "senile."

The essential constituent of the living machine is protein. The work which the machine does is combustion in the main, and for this purpose it needs fuel. These fuels will burn outside the body, as they do within it. An inorganic machine could be run on the combustion of sugar, just as the body can. The first dietetic need, then, is for fuel, and the fuel-foods are the fats and the carbohydrates, starch and sugar. But the body, unlike all inorganic machines, is itself being broken down and remade from moment to moment. Therefore it requires supplies of its own special constituent, which is protein. Ideally, then, we should consume just so much protein as is necessary for tissue-maintenance, while all our energy should be derived from the mere fuel-foods. This would be the monetarily cheapest diet, but it would also be physiologically cheapest.

Proteins can be burnt, like the pure fuel-foods. If the supply of pure fuel be deficient, as perhaps in a few persons who take very little sugar, or potatoes, or fat, then the necessary energy must and will be obtained by the combustion of protein. But far more often this combustion is necessary not for the sake of the energy it produces—for plenty of fuel is at hand for that—but because the protein supply is very much in excess of the requirements of tissue-maintenance, and therefore the excess must be burnt, simply in order to get rid of it.

The Ashes Left to Clog the Body when Superfluous Foods are Taken

The normal body might simply excrete protein, as such, by the skin or the kidneys, but it does not and cannot. There is nothing to be done with it but to burn it up, and the ashes clog the machine.

The virtue of the pure fuels is that they leave no "ashes." Nothing could be more entirely perfect than the physiology of the combustion of starches and sugars, so far as we know. They yield only two substances, we believe, at any rate, in the normal body, one of them being carbonic acid and the other water. The former is removed by the lungs, with ease and completeness; and the latter, so far from being a poison, is the solvent, the diluent, and the vehicle of poisons, carrying them away from the body with it. Now, if we take more fats and carbohydrates than we need, there are two possible consequences, both of which follow, in varying proportions, in almost everyone. The surplus may be stored. All except the desperately emaciated have stores of fuel, in the form of fat, deposited in various parts of the body.

Tha Value of Fat as an Aid to Beauty and a Stored Reserve of Fuel

In reasonable quantities and in suitable distribution this fat is valuable; it gives beauty to the contour; it forms a physical protection against hard surfaces; it economises the outflow of heat from the body, as conspicuously in the case of the whale, with its blubber, and the Eskimo; and it furnishes a reserve of fuel which can at any time be called upon when, for any reason, the usual supply from without is not being maintained. It is the patient's own fat that the doctor relies upon for the maintenance of energy in the course of an acute tonsillitis, or fifty other illnesses, where, all

over the country, doctors and patients' friends are daily struggling, the latter for more food to "keep the patient's strength up," and the former for something like starvation, to permit the patient to use his strength for the urgent business of conquering his enemies. If no one carried any fuel about with him, we should indeed be in continual danger of death from inanition—by far and away the rarest form of death known to medical science.

People who Store Fat Harmlessly and Those who Store it Dangerously

People vary widely, by nature, as to the amount of fuel they store. Some will never store enough, however much food they take; and others will always store an unwieldy and unsightly and even mechanically dangerous quantity—as in "fatty infiltration of the heart"—though they do their best to keep their diet small. The fuel which is not stored is burnt, and the penalties for taking an excess of fuel which is burnt are very light. There is the lost labour of digestion, and there is the need for getting rid of rather more heat than need have been produced. That is all.

But when we turn to protein excess the case is utterly different. The bodily combustion of proteins is, at the best, a most imperfect process. If it were perfect, the products should be merely carbonic acid and water; while the nitrogen which is characteristic of all proteins might just remain as free nitrogen, inert and harmless, such as our blood always contains. Nothing of the kind happens. We may now be able to name a score or so of the products of protein combustion in the body, and there may be hundreds awaiting discovery. The proteins are the most complicated chemical substances in the world. They differ among themselves, every living species having proteins of its own which none other has, and the products of their combustion or oxidation vary likewise.

The Evidence Accumulated in Favour of Fletcher's "Low Protein" Diet

Now, everyone knows that decomposing food is liable to upset us, because it comes to contain rank poisons. No doubt proteins do not often undergo those particular decompositions in the body, fortunately for us, but that they yield poisons is beyond question. Ought we not, therefore, to confine our diet, as regards proteins, to only such quantities are as necessary for tissue-maintenance, with perhaps some unknown quantity besides for the manufacture of protective substances in the blood?

The proof of the pudding is in the eating; the proof of gravitation is in the discovery of Neptune; the proof of Listerism is the healing wound. We now have more than a decade of actual trial of "low protein," or "economic nutrition," behind us, and the results do seem to be most favourable to its practice. No one, of course, disputed the assertions regarding the influence of "Fletcherism" upon himself which were made by Mr. Fletcher. He told us how his health improved in every way, but his case might have been exceptional. We all differ. He might have been suffering from some special infection, or chemical disorder, which his new diet happened to relieve. But the case is now changed. For single enthusiasts we now have scores; for believers in theories, or for personal friends of Mr. Fletcher, we now have many unbiassed persons, squads of soldiers, classes of students, and so forth, upon whom the new theories have been systematically tested.

The verdict of time also seems to be favourable. At first it was a fair question how long the good results could last. Their appearance might well be due to the body's opportunity of getting rid of poisons, but thereafter it might succumb slowly to the effects of persistent slight starvation.

The Case for Self-Poisoning Proved Against Surplus Protein

The passage of years seems to have answered that question definitely in favour of "economic nutrition." Even a carnivorous animal, such as the dog, has been found to thrive on a low protein diet, to go on thriving, and actually to increase in weight. As for man, he seems to benefit in every way—the elderly almost cease to grow "old"; the athlete becomes stronger, fitter, quicker; the student studies better.

These are the results which large numbers of responsible people have laid before us, and it seems very difficult not to accept them. The only course for objectors is clear. They incline, hitherto, to protest, to appeal to authority, rather like Galileo's opponents, who found no mention of Jupiter's moons in Aristotle, but not to meet experiment by experiment. That is what the critics of "economic nutrition," in Germany, and in this country, now require to do. No doubt the advantages of men of science in America are great. There is plenty of money, and always a host of young people of both sexes who are ready to be the subject of experiments—even tiresome and prolonged experiments. But hitherto we have done practically nothing

at all in Europe to back up our criticisms of Chittenden's work; and meanwhile we cannot doubt that, on the whole, he has taught us all a very important lesson, that directly bears on questions of personal hygiene, and on the personal and national economics which are so largely concerned with paying for our food supply.

The theory of self-poisoning, or auto-intoxication, by means of surplus protein must undoubtedly be accepted henceforth. This may take various forms, no doubt, but the fact remains. There may be actually poisonous constituents in certain foods which simply show their effects when much of those foods is taken. There may be auto-intoxication due to the decomposition of proteins by microbes in the bowel, and the absorption of the poisonous products. With that we must deal when we come to study the care of the bowel. Then there is the auto-intoxication due to the imperfect oxidation, within the tissues of the body, of surplus proteins which have been absorbed from the bowel by the blood. In Professor Chittenden's judgment, about two ounces of protein represent the daily need of a man of average size, personal idiosyncrasy being left out of the question. Any intake of protein beyond this quantity may thus be looked upon as preliminary to some degree of auto-intoxication.

How can Senility be Avoided and Health be Retained in Old Age?

We all know the name of the great European student of auto-intoxication who works in Paris. Professor Metchnikoff has subjected the work and theory of Chittenden and Fletcher to some criticism, in his book on "The Prolongation of Life." Both parties are really making for the same goal, and have the same principles. Appproaching the matter from different angles, they agree entirely in alleging that many of our minor ills and incapacities, and, later, our degenerations and so-called "senility," are due in the main to auto-intoxication, and they set themselves to avert it. We may confidently learn from their agreement so far. But when it comes to prescribing, "doctors differ." The "Fletcherite" prescription is, above all, slow eating, whereas Professor Metchnikoff declares for sour milk. It is more than probable that far too much has been claimed for both of these measures.

Mr. Fletcher's prescription of extreme mastication has been carefully examined. Observation of the lower animals shows that they vary in procedure. The dog bites its food, and then swallows it. The horse comminutes its food to an extreme Its soft palate is so close to its tongue that it cannot even breathe through its mouth and this anatomical arrangement favours the extremely complete treatment of the food, and its very thorough mixture with the saliva. Man is normally an eater of the class of the dog rather than the horse, but Mr. Fletcher wishes us all to treat our food as the horse does. We can do so, if we like, by the use of the soft palate.

Scientific Experiments in Slow Eating by American Students

According to Mr. Fletcher, we should chew our food until all taste has gone out of it. He thinks he has discovered in himself, and that others have discovered in themselves, a peculiar reflex action, by means of which the food is automatically swallowed when chewing is really complete; and he believes that we ought all to develop this reflex, and never swallow without it. Professor Metchnikoff opposes the "Fletcherite" view in this respect, and regards the attention of Fletcherism to excessive mastication as itself excessive. No doubt the criticism is just, in degree, but we should all be grateful for what has been learnt in America by experiments on this subject.

Some years ago nine students of Yale University resolved to test the virtues of mastication. They set themselves "to masticate thoroughly every morsel of food, with the attention concentrated not upon the mechanical act of chewing, but upon the taste and enjoyment of the food; and to follow implicitly and absolutely the dictates of the appetite both as to the amount and kind of food chosen."

The results were that the total quantity of food taken was slightly reduced; the proteins, especially the flesh-foods, were very greatly reduced; the burden of excretion was diminished; the excreta of the bowel were reduced. and microbic processes in them reduced still more; there was a slight loss of weight and strength, an enormous increase of physical endurance and a slight increase in mental alertness.

The Disadvantage of Extreme Attention to Methods of Health Preservation

These, of course, are very interesting and valuable results. Are they due to thorough mastication as such? The probable answer is that they are not. The extreme mastication prescribed by Mr. Fletcher and practised by these experimenters has the effect of reducing the amount of protein taken, to

a very great extent, and the rest follows. That, at any rate, seems to be the answer. If we practise "Fletcherite" mastication, however, we get no special advantages from it in itself, simply because it is so very much more than simply efficient mastication; and we run the risk, if we are nervous people, inclined to be hypochondriacal, of developing a sort of mania or obsession on the subject, to which Metchnikoff refers, and which is certainly not worth having. But if we must admit that excessive mastication is our only effective route to a reduction in the protein we consume, then it will probably justify itself.

This question has been very carefully and recently studied by Dr. Alexander Bryce, in his excellent book on "Modern Theories of Diet." He points out why "fletcherising" tends towards a reduction in protein and towards vegetarianism. "The longer carbohydrates are masticated, the sweeter they become, from the development of saccharine material; but as proteins have no flavour other than that imparted by the extractives with which they are associated, there is no pleasure to be derived from their prolonged retention in the mouth, and the tendency is to reduce their quantity." We may remember that Dr. Keith discovered and taught this decades ago. Thus, in common with the herbivorous and graminivorous animals, which "fletcherise" their food, the "Fletcherite" tends to become a vegetarian, depending largely on grains, cereals, and fruits. After a very careful study, Dr. Bryce ends his chapter on this subject as follows: "The conclusion at which we must arrive is that during health nothing more than ordinarily careful mastication is necessary, and that, if permitted at all, the exaggeration of this function as represented by Fletcherism should be reserved for certain classes of dyspeptics."


"THE ATTACK." After a painting by W. Hunt

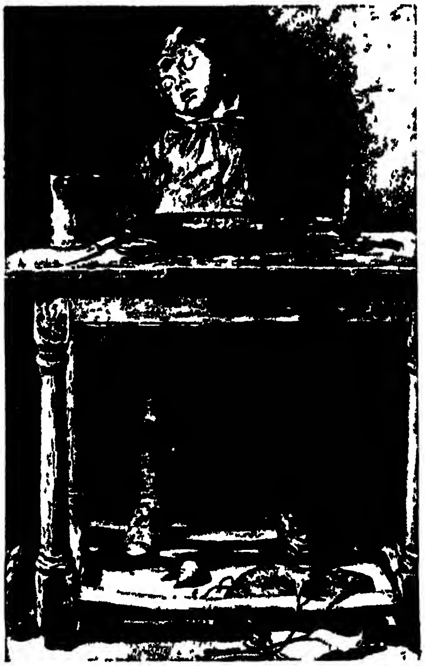
We must thank Mr. Fletcher, therefore, for recalling the importance of mastication to our notice, but we cannot accept his view as to the extreme degree of mastication which we should practise, nor his intense fear of allowing any useless material to enter the bowel. As Dr. Bryce says, "the weight of evidence is against the removal of all tasteless, solid residue after the 'fletcherising' process is complete." Mr. Fletcher would apparently like to reduce the excretory activity of the bowel to vanishing point, by allowing nothing whatever to be swallowed that is not absorbed. Certainly, Fletcherism does reduce the requirements of excretion to a great degree; but it is a very crude physiology which supposes that the bowel excretes nothing but the surplus or innutritious part of what is swallowed.

The liver pours its excretion, which we call the bile, into the bowel. The blood pours certain waste or dangerous substances into the bowel directly through its wall—a fact only lately appreciated, and probably very important. These substances, the excretion of which has nothing to do with the food that enters the bowel, are mainly fluid. They require to be sopped up, so to say, by more or less solid matter in the bowel, matter which thus acts partly as a sponge and partly as a sort of ballast, which stimulates the bowel to do its work properly, as we shall see. Thus we are not entitled to assume that everything which enters the mouth but is not absorbed is useless. Everyone will agree that an aperient may be useful, and so may aperient food. If the body itself did not pour excretions into the bowel, the Fletcherite argument would hold that, if we introduce nothing superfluous into the bowel, there is no occasion for the bowel to do anything; but that is not the case.

One of the most obscure and important of diseases is appendicitis. Our understanding of it is painfully inadequate. It is commonly looked upon as a new disease, but that is a mistake. Evidence has been found in mummies of its occurrence in ancient Egypt thousands of years before our era. It was only too familiar to our nearer predecessors under the name of peritonitis. We know now that this

peritonitis, inflammation of the peritoneum, or membrane which covers the bowels, has its origin very commonly in the "appendix vermiformis" of the bowel. This knowledge, combined with Listerian surgery, enables us to cure appendicitis in thousands of cases annually, so that the almost desperate stage of peritonitis is never reached.

But this saving of lives is not enough while so many are still lost. The disease should be prevented, but we do not understand its causation. It is due to microbes, of course, having every characteristic of a microbic infection. But we cannot trace a specific microbe, peculiar to the disease, though we are sure that cherry-stones and similar objects are practically free from blame. They may cause one case in ten thousand. The "normal" inhabitant of the part of the human bowel which is called the colon—namely, the *bacillus coli*—is probably responsible. What excites this morbid activity? Constipation, we naturally think, must predispose to it, but we find that appendicitis is commoner among active young men than any other section of the community, and they are the least constipated of all adults. The puzzle therefore remains. This is not the place for an elaborate examination of one of the most obscure and pressing problems in pathology; but no one can study carefully the records of Mr. Fletcher's own case, and those of his many followers, without wondering whether the key to appendicitis may not be found along the lines which he has followed. Under his *régime* the microbic content of the bowel almost disappears, or, at any rate, is deprived of its activity.


"THE DEFEAT." After a painting by W. Hunt

It will be very strange if we do not find the key to appendicitis somewhere in the still secret details of the chemistry of diet. At least, we know two facts—first, that the disease is microbic; and second, that diet profoundly determines the microbic content of the bowel, as we might expect. The indication, therefore, as the present writer has already suggested elsewhere, is for a statistical inquiry into the incidence of appendicitis in relation to dietetic habit; and, as a first step, which might almost turn out to be the last, the now large company of Fletcherites would do a great service by ascertaining the frequency of the incidence of appendicitis among themselves, together with special bacteriological examination of such cases as do occur. It may be hazarded that the incidence will be found to be extremely small, and, if so, an obvious clue will have been discovered.

However that may be, we have reached certain definite conclusions, thanks to the work of various independent schools of contemporary workers. They are making it more certain every day that nine-tenths of what we call "old age," "senile changes," "premature senility," "tissue degeneration," and so forth are due not to time but to toxins; that they are the results neither of destiny nor starvation, but sheer intoxication, which may be avoided in a large degree by great moderation, and which may be completely avoided when we know more. This is the really important aspect of the food question today. The faddists may fight as long as they please over the relative merits of this particular article of diet as against that—it usually matters little. But if it should be proved that, qualitative questions apart, the quantity of food consumed by nearly all but the very poor is highly excessive; that this excess, whether after absorption or under the action of microbes in the bowel, involves the continuous exposure of the body to poisons; that, as Metchnikoff declares, a man should be old not at seventy, but at a hundred and twenty; that it is possible to gather decades of experience without growing old; that life may be active, happy, and profitable to self and to others in the eighties as in the twenties; and that thus, like General Booth, Sir Francis Galton, and many other famous octogenarians, we may all justify in the deepest sense the old saying that "those whom the gods love die young," then, plainly, the food question is worth discussion after all.

THE SUN AS AN ARTIST

The Wonderful Powers of Vision that Have Been Derived from the Camera

PHOTOGRAPHY IN NATURAL COLOURS

In science the fact that seems most trivial often proves of vast importance. Very trivial, for instance, appears the fact that certain compounds of silver quickly blacken on exposure to daylight. But it was by combining this disregarded scrap of curious knowledge with another equally curious but apparently useless fact which the enemy of our youth, Euclid, had casually observed that mankind was endowed with the most extraordinary of powers. Euclid noticed that when a small hole in a darkened room allowed the light in the street outside to enter, a picture of what was going on in the street was visible on the back wall of the darkened room. Supposing a tree stands at some little distance from a room in which all doors are closed and all windows shuttered. If there is a little hole in one of the shutters, the rays of light that strike against the tree will be reflected in various directions. Some of them will pass through the hole in the window-shutter, and fall upon the back wall of the room, and form there a small but clear picture, in natural colours, of the tree. In sunny Eastern lands, where the houses are dark within, while the scene outside is brilliantly lighted, this strange projection of images through a small hole must have been noticed since the dawn of civilisation.

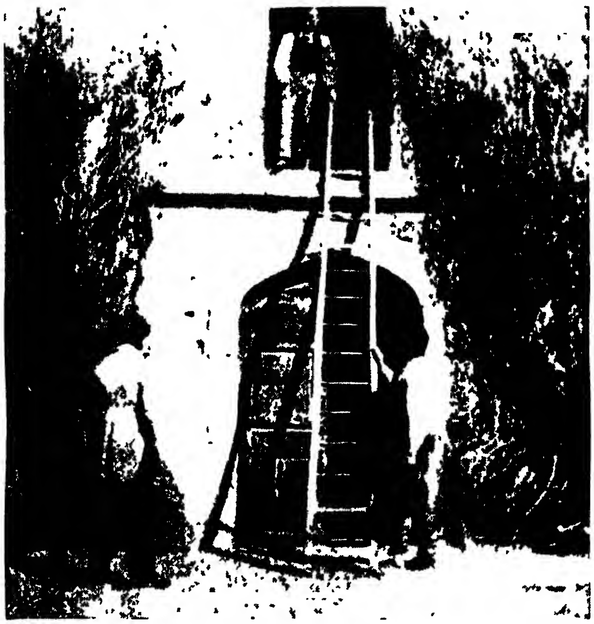
The modern camera is merely the reproduction, on a small, scientific scale, of the dark room in which Euclid used to amuse his pupils by opening a small hole in a shutter. And the modern photographic plate is simply coated with some chemical compound which, like nitrate of silver, grows quickly black in the sunlight. An excellent photograph can be obtained by knocking out one side of a cigar-box, and fixing in place of it a thin sheet of metal in which a pinhole is made. The reflection of a broad stretch of landscape will be cast on the side of the box opposite the pinhole; and if a photographic plate is inserted there the image will be recorded in a clear and vivid manner. The only disadvantage of a pinhole camera is that the rays of light entering through the tiny hole are very feeble, and a longish exposure is necessary in order to obtain a good photograph. As a matter of fact, the modern camera was used as a scientific and artistic toy long before the photographic plate was invented.

In its earliest form it was the camera obscura, that used to be found in many popular holiday resorts. One entered a little dark chamber, and there saw a clear and lively picture of, say, the sands of the seaside town, where the camera obscura was being exhibited; and the scene and the figures of the crowds of holiday-makers were reflected through a lens in the roof on to a mirror. The writer still remembers the sense of wonder with which in childhood he watched these real-motion pictures in a camera obscura near the sands of a little town on the coast of East Anglia. Very likely Roger Bacon, who anticipated so many modern scientific inventions, was the first man to make one of these dark picture-rooms. For, in his "Perspectiva," written about 1267, he describes an apparatus with a mirror, by means of which it is possible to see images of what is going on in the street, so that "those looking will run to the image and think the things are there, when there is nothing but a mere reflection." The first practical use of the camera was made in 1568 by Daniello Barbaro, a Venetian artist. In his work on perspective, Barbaro gives the following elaborate instructions.

"Make a hole in the window-shutter of a room, and fit into this hole one of the spectacle-glasses that aged men use. Shut all the doors and windows, so that no light may enter the room, except through the

spectacle-glass. Take a sheet of paper, and bring it gradually in front of the glass until you find the proper position. Then you will perceive on the paper the image of the things as they are, the gradations, colours, shadows, movements, clouds, the rippling of water, birds flying, and every visible thing. If you cover the glass so that you leave only a little hole in the middle, you will get a brighter effect. And, seeing on the paper the outlines of things, you can draw all the perspective with a pencil, and put in the shading and colouring according to Nature, holding the paper tightly until you have finished the drawing."

Made in a portable form this kind of instrument was used by many amateur artists in the eighteenth century. And it was by continually drawing the images projected through the lens that two or three men began the search for the chemical preparations which should record the pictures projected by the rays of the sun into the little dark chamber.


AN EARLY PHOTOGRAPH BY W. H. FOX TALBOT

Nearly all the main advances made in photography, however, were due to happy accidents. It is not extravagant to say that photography is the one great modern science which was built up by chance. Long after the camera had been invented, men saw that various silver compounds were blackened by exposure to sunlight. But they could not conceive it possible that the light of the sun, which brightens and illumines the world, could produce blackness on anything it fell upon. So they thought that the discoloration was a kind of rust or tarnish made by the air. But a German chemist, J. H. Schulze, wanted to treat some chalk with nitric acid, and, having at hand some of the acid in which a little silver had been dissolved, he used it. He was working near a window, and he was surprised to see the mixture in the dish turn dark where the direct rays of the sun struck it, while the parts that were in the shadow remained unaltered. Putting aside the work on which he was engaged, he set out to find what it was that blackened in sunlight.

He mixed some chalk with nitric acid and obtained no result. Then, after several vain experiments, he remembered the silver, and by preparing a stronger solution of nitrate of silver he obtained some striking results. At first he thought it was the heat of the summer sun that caused the extraordinary change. But on testing this idea before a strong fire, with the nitrate of silver exposed to great heat, but screened from the radiance of the flames, he found that heat was not the active agent. And when he placed a sludgy mixture of chalk and silver nitrate in a bottle, wrapped in thick paper in which letters and figures were cut, and set the bottle by a window, he obtained the first true photographic impressions. For when the paper was removed from the bottle the letters and figures could clearly be seen in dark outline on the chalky mixture. Schulze amused himself by stirring up the bottle and so removing the images, and then getting fresh impressions by means of pieces of paper cut out in a different manner.

This happened in 1727, but many years passed before the second and more important step was taken. At last, in 1790 Thomas Wedgwood, the son of the famous potter, was struck with the idea that the curious property silver nitrate had of blackening in daylight might be put to a wonderful use. Wedgwood was but a boy, stricken with an illness that carried him off in early manhood, but he had a remarkable brilliance and maturity of mind. He began by moistening a sheet of white paper with a solution of a silver salt, and put a fern-leaf on the paper and exposed the two objects in a strong sunlight. In two minutes the paper turned a brown-black; and when the leaf was taken away a white outline appeared on the dark

ground. Wedgwood continued his experiments for twelve years, and, helped by Sir Humphry Davy, he succeeded at last in photographing a small image through the lens of a camera on to a sheet of prepared paper. All this, we must admit, was accomplished by scientific experiment. Nothing was due to accident.

But it was an accident that prevented Wedgwood from completing his work of discovery. In his best photographs there was a small image in light outlines upon the blackened sheet of paper. The light outlines represented that part of the silver salt which had been protected from the action of the sunlight, by darkish reflections of the forms and shadows of the object photographed. But when this picture, drawn by the chemical action of light, was taken out of the dark camera and examined in daylight, it quickly faded away. Wedgwood vainly tried to fix the image by washing it and varnishing it. What was needed was a chemical that would wash away the unaffected silver salt from the plate, leaving nothing remaining on the outlined image that the sunlight could affect. This could have been done by the hyposulphite of soda that had recently been discovered. But Wedgwood died in 1805, only three years after the publication of his first invention, and no one continued his search after a fixing agent.

PINHOLE PHOTOGRAPH OF KENSINGTON PALACE FOUNTAINS

For more than a quarter of a century after his death the silver compounds were neglected by other experimenters in photography, because of the apparent impossibility of fixing the image obtained by means of them. The result was that later researchers did a great deal of work in a wrong direction. The right road was not rediscovered till after a brilliant and patient French man of science, J. N. Niepce, obtained a photograph on a plate of silver thinly coated with a kind of asphalt. The asphalt plate had to be exposed for six or eight hours in sunlight before the image was printed upon it. This was much too long for any practical purpose; and with the help of a scene-painter of Paris, L. J. M. Daguerre, Niepce worked out a quicker process. The two men became partners; and though Niepce died before the invention was perfected, and Daguerre claimed the entire credit for it, there can be little doubt it was a joint invention. A silver plate was polished with exquisite care, and then held over some heated iodine. The iodine vapour acted on the surface, and formed there a coating of iodide of silver. The plate was then placed in the camera, and, after a still longish exposure, an image was formed upon it by the action of light on the silver salt. Then the fixing was done by washing the image in water in which ordinary salt had been dissolved.

This process was discovered quite accidentally. In the asphalt treatment Niepce used a little iodine, which is a substance obtained from seaweed. It chanced that a plate of silver had a silver spoon laid on it; and when Daguerre took up the spoon he found that its image had been printed on the plate. On examining into the extraordinary affair, he found a trace of iodine on the plate; and the probability is that the two partners at once turned their attention to the iodising process. But they could only get faint images of bright objects after many hours of exposure. After Niepce's death, things seemed to get worse. One day Daguerre removed a prepared plate from the camera, and found no image at all upon it. Very likely there was a poor light that morning. Had the spoilt plate been made of paper, it would no doubt have been thrown away. But as it was made of silver, Daguerre put it in a cupboard, with the intention of re-polishing it the next morning, and treating it again with iodine vapour.

But when Daguerre took the plate out the next day he was wildly surprised to find upon it a clear and distinct picture.

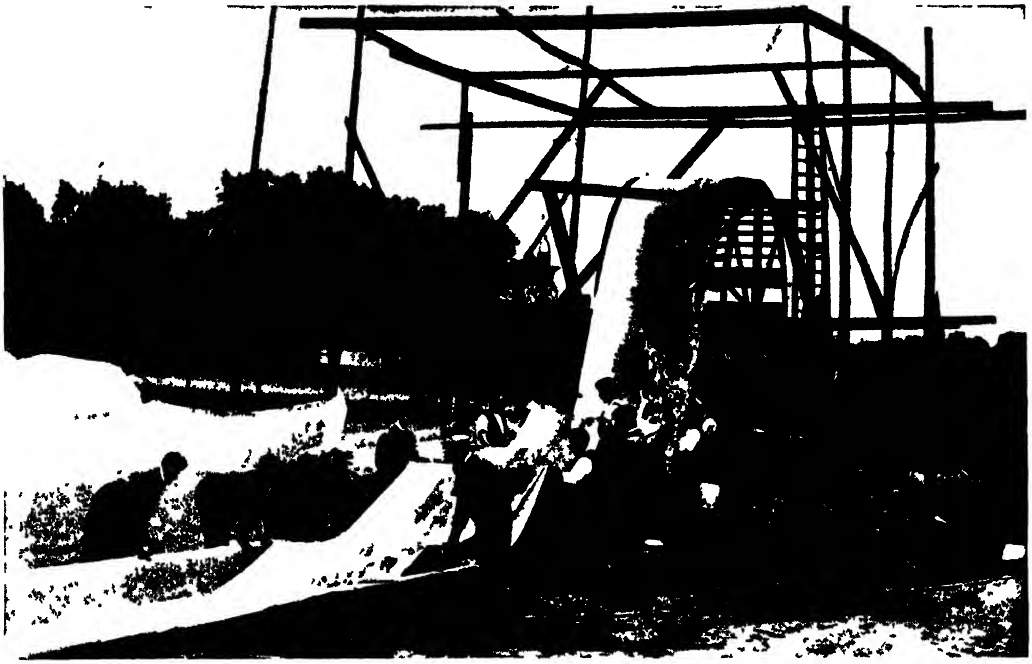
FLASHLIGHT PHOTOGRAPH OF SOLDIERS IN BIVOUAC

Was there something about the cupboard that produced this extraordinary effect? Daguerre resolved to find out. He submitted another prepared silver plate to a short exposure in the camera, and put it in the magic cupboard. The next morning a distinct and well-defined image was visible upon the second plate. Now, the cupboard was one in which were stacked all the chemicals that Daguerre and his dead partner had been testing. So the only way of finding out what it was that produced the image was to keep on putting plates in the cupboard, day after day, taking out on each occasion one of the chemicals. It was not until a dish of mercury was removed that the image failed to appear on the plate.

FLASHLIGHT PHOTOGRAPH OF A LION IN ITS NATIVE HAUNT

So Daguerre discovered that, when an iodised silver plate was treated with mercury vapour, the latent invisible image, which the sun had printed on the salt after only a short exposure, could be quickly developed into a clear, visible picture. Such was the origin of the first practical modern process of photography, which Daguerre revealed to a few friends in 1838. A few years afterwards daguerreotypes were being taken all over the civilised world. A portrait often cost eight guineas, but rich people did not grudge the money. And they were not dismayed by the fact that they had to sit for half an hour in strong sunlight, to enable even the latent, invisible image to be made on the prepared plate of silver. Everybody was amazed and delighted at the strange and wonderful method by which the sun was made to draw their portraits. And Daguerre and Niepce's son were rewarded by the French State with pensions of six thousand francs and four thousand francs a year respectively.

Then another happy accident inspired an English man of science, William Henry Fox Talbot, with a more important idea than Daguerre's. English amateurs of photography had resumed the experiments



PREPARING THE LARGEST PHOTOGRAPH IN THE WORLD—A PANORAMA OF THE BAY OF NAPLES

of Wedgwood, and Talbot himself had succeeded in 1835 in taking a photograph on a sheet of oil-paper, treated with nitrate of silver. Not only did Talbot fix the image, but he used the finished translucent photograph as a means of making a great number of copies of the pictures he took. In Daguerre's silver plate method only one photograph could be obtained on the plate — no copies could be made. But Talbot was able to place a second sheet of prepared paper beneath his actual finished photograph, and expose them both for a few minutes in the sunlight. He thus obtained another picture on the second piece of paper. And this printing process could be repeated many times. But though this discovery is of great importance from the commercial side of photography, it is not Talbot's main achievement in the new science. The talbotype did not become superior to the daguerreotype until a happy accident helped the English inventor to arrive at a fine, quick, beautiful, and easy new method.

A LONG-FOCUS CAMERA FOR PHOTOGRAPHING DISTANT PANORAMA

It happened that many English amateurs, who kept to Wedgwood's ideas, found, as he did, that white kid leather was a better photographic material than paper. One enthusiastic clergyman cut up all the gloves of his family in order to get pieces of leather that he treated with nitrate of silver, and inserted in his camera. When all the gloves had disappeared, he was still anxious to go on taking photographs. Rather than do nothing, he had the idea of trying to tan paper to make it act like leather. He took some gall nuts, and made a solution with them, and tanned some paper, and tried it. It was just one of those wild and extravagant notions that sometimes occur to the happy amateur of any science, and lead him to make experiments that no practised man would dream of. In this case, the experiment was very fortunate, and the clergyman who performed it told his friends rejoicingly that his tanned paper shortened in a marvellous manner the time needed for exposure.

MAKING UP A COMPOSITE PHOTOGRAPH

THE FIVE PHOTOGRAPHS OF DETAILS WHICH FORM THE PICTURE ON THE OPPOSITE PA[GE]

THE COMPOSITE PHOTOGRAPH FORMED FROM THE FIVE PHOTOGRAPHS ON THE OPPOSITE PAGE

The photographs on these two pages, the work of Mr Horace Nicholls show what can be done by combining small photographs

Talbot heard of the affair, and investigated it in a scientific way. He found that an acid made from gall nuts and slightly washed on the oiled transparent paper he used for taking negatives had the peculiar property of making the latent image visible during the exposure. And when more gallic acid was poured on the photographic image it brought out the picture in a very quick and clear way. By combining various silver compounds with gallic acid and other chemicals, Talbot fully established the modern method of photography. His process was better than that of Daguerre. It did not tire the sitter; it enabled a beautiful, delicate variety of tones to be achieved; and by means of it there were produced, especially by David Octavius Hill, a well-known Scottish painter, portrait-photographs which have never yet been surpassed for pure and lovely artistic qualities.

On Talbot's method of developing the latent image on a photographic plate, the development processes of the present day are based. And Talbot's method of taking a negative upon a translucent material, and then printing copies from it, is the fundamental invention from which modern printing processes are derived. Daguerre's mercury-vapour bath is but an historical curiosity; and so are the portraits produced by the professional photographers who adopted his methods. Some talbotypes, on the other hand, are still things of rare beauty. And seeing that Talbot took and fixed his first photograph in 1835, when Daguerre could only obtain the faintest of images with his silver plate process, there seems no reason to attribute to the Frenchman, who probably stole some of Niepce's ideas, all the glory of the sound, constructive, pioneer work in one of the most useful scientific arts of modern times.

In one way Talbot was also the inventor of the most valuable thing in photography—its instantaneous action. For though his process was usually rather slow, yet with special care it could be made to act in about a millionth part of a second. This was shown by an interesting experiment performed at a meeting of the Royal Institution in 1851. Taking a newspaper, Talbot fastened it to the end of a wheel, which was then set in rapid motion. The lights in the hall were put out, the lens of the camera was left open in the darkness, and a momentary illumination was produced by a spark from an electric battery. The photographic plate was at once developed, and it was found to contain so well defined a picture of the newspaper that not even a letter was indistinct. The specially prepared plate must have been extremely sensitive, for the illumination obtained from an electric spark of the kind used by Talbot only lasts about one-ten-thousandth to one-millionth part of a second.

AN INSTANTANEOUS PHOTOGRAPH OF TWO GREYHOUNDS RACING AT FULL SPEED

This extraordinary rapidity of action was, however, quite exceptional. It could not be obtained in an ordinary way. The efforts of later experimenters were devoted to the slow and difficult task of making instantaneous photography an easy and common method. Here our countrymen succeeded in keeping for many years in advance of foreign experimenters. In the middle of the nineteenth century a British sculptor, Frederick Scott-Archer, worked out a new process which required an exposure of only ten seconds. This was the famous wet-collodion process, in which guncotton was dissolved in sulphuric ether, and poured on a glass plate, the coated plate being immersed for a minute in a bath of nitrate of silver. In 1878, the gelatine dry

plate was invented by Mr. Charles Bennett; by means of it, photographs could be taken in one second. And now, after thirty-six years of laboratory experiments, the sensitiveness to light of the various chemical preparations has been so much increased that clear pictures can easily be made in one-thousandth of a second.

The marvellous control which man has obtained over the resources of Nature is more fully displayed in the progress of modern chemistry than in any other field of science. Forms of matter change under the hands of the modern chemist into myriads of new combinations, each of which is a special creation. The chemistry of photography is only a little corner in the immense field in which the new alchemist works his wonders; and yet it shows on a small scale somewhat of the sudden and mighty increase of power that we have obtained over natural resources. When photography was quite in its infancy, an exposure of six hours was required to obtain a recognisable picture of any object. And later, in the first portraits taken by Daguerre, the sitter had to remain unmoved in brilliant sunlight for half an hour. Now even one-millionth of a second is more than is required in the latest electric spark method of photography. So infinitely sensitive to light are the finest photographic films that they produce clearly a picture of a thing lighted by a flash that endures only for one-tenth of one-millionth of a second!

PRESS PHOTOGRAPHY FROM THE DIZZY HEIGHT OF A NEW YORK SKY-SCRAPER

The human eye is a very poor instrument of vision. The colours it cannot see are enormously greater than the little rainbow of light which is visible to it. We live in a dark prison, with only a low, narrow dungeon slit, through which we can dimly peer at the sunlight world. It is true that we have lately invented in the microscope and telescope a means of enlarging our powers of sight. But these two instruments do not give us any new powers of vision; they only magnify our poor natural faculty.

The photographic film, on the other hand, has now endowed us with a wonderful new vision of extraordinary range. It has given us eyes that never tire; and when these eyes are placed behind a telescope the universe flashes out, arrayed in new hues of infinite beauty, and charged with new forces of strange perplexity. And the universe, moreover, is so enlarged that light from the farthest sun shown on the photographic film takes one thousand million years to reach us. Let us put it in another way. So sensitive is the modern photographic plate that it records light-waves which began to travel from their source towards the earth at a time when the planet on which we live had not begun to exist.

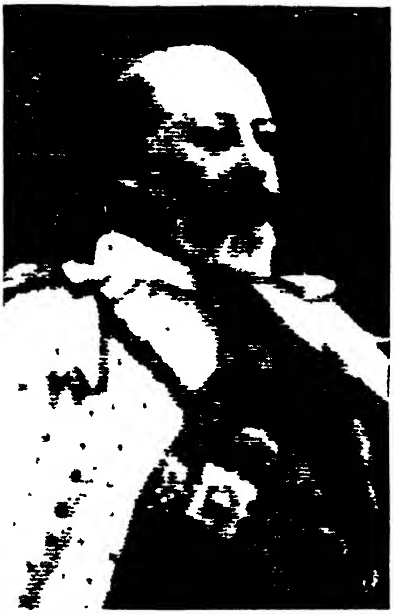
And all this comes from Tom Wedgwood experimenting, a little more than a hundred years ago, with a silver compound which blackened when exposed to daylight. Many persons regard photography merely as a pretty addition to the small pleasures of life. But, as a matter of fact, the photographic camera and the photographic film are the most exquisite and powerful of all the instruments of modern science. At the

THE INSTANTANEOUS WRITING OF CONTEMPORARY HISTORY BY THE LIGHT OF THE SUN

A PHOTOGRAPHIC RECORD OF A HISTORIC EVENT—THE BOMB ATTACK ON THE KING OF SPAIN AT MADRID IN MAY

present time Sir J. J. Thomson is engaged in splitting up various elements into thousands of hitherto unknown substances. Probably as he goes further into his new method of discovery the number of strange, novel combinations of matter which he is finding out may swell to tens of thousands. The work is being done by attaching photographic plates to the side of an empty glass tube, in which various elements are made to enter into new compounds by an electric discharge.

Wonderfully varied are the uses of the modern photographic film. Attached to a microscope, it is employed, with the invisible ultra-violet rays, to reveal very minute objects that our eyes can never actually see by means of the most powerful combination of lenses. Infinitesimal things, that are unseen in the long waves of light to which our eyes respond, can be revealed by flooding them with ultra-violet rays from a mercury lamp, and then photographing them. The chemicals used on an ordinary photographic plate or film do not record light in the way that our eyes do. They are unaffected by the long light-waves which, so to speak, make up red and yellow colours. It is for this reason that in an ordinary photograph red and yellow objects come out in black masses. In the photographic portrait of a woman with a red dress of pure tint, for instance, the dress would appear to be very dark. On the other hand, the chemicals usually employed on a photographic plate are very sensitive to the short waves of light. Blues and violets are rendered very distinctly, and the invisible colours that stretch beyond the violet end of the spectrum are also reproduced.



A PHOTOGRAPH TRANSMITTED OVER THE TELEGRAPH WIRE

They were, indeed, discovered for the first time by a man of science who placed a paper moistened with nitrate of silver at the ultra-violet end of the spectrum. As is well known, the spectrum is a rainbow band of colours produced by letting the light from the sun or a star or a furnace fall on a prism of glass, or on a small piece of metal ruled with a marvellous number of very closely engraved lines. A spectrum of sunlight consists not only of a few colours, but of many thousands of tiny narrow dark streaks. These streaks are clearly seen when the spectrum is reflected on to a photographic film, and there enlarged and recorded and fixed. The streaks are indications of the various elements which are burning in the sun or star or furnace; and it is by studying them that chemists and astronomers analyse the matter of our earth, or ascertain the various materials that are flaming in the fiery gases of some heavenly body thousands of millions of miles away from the world. By means of a photographic film, modern astronomers are now mining into our sun, and obtaining wonderful pictures of vast, flaming storms of swirling masses of iron and other elements, reduced by the tremendous heat into wild clouds of gas.

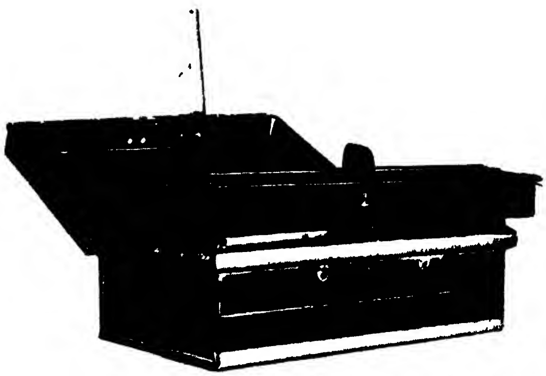
The infinitely large, the infinitely remote, and the infinitely small are being brought within our feeble range of vision by the photographic plate and film. Even so mundane a matter as the detection of a burglar, who has robbed a house and got off safely with his spoil, can often now be investigated by means of the camera. A finger-print on a window, or on some other suitable object touched by the criminal, may not be clearly visible to the unaided eye, especially if there is practically no dust upon the smooth surface.

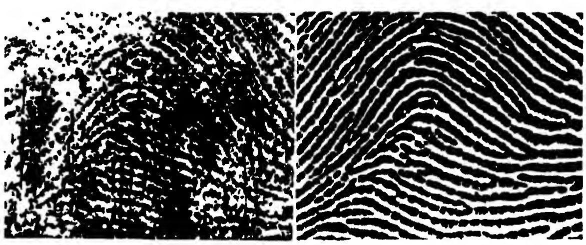
But in many cases the camera will throw on a photographic plate a clear impression of the dim marks. And if the wrongdoer can be traced by suspicion, or if he is a criminal whose finger-marks are recorded already by the police, the evidence of the photographic plate will be sufficient to make him as well known as if he had left a visiting-card behind him. And very soon it will be easy, when the portrait of a criminal is in the hands of the police, to flash copies of it in a few minutes all over the country.

Telephotography, by means of which a picture is sent for hundreds of miles over a telephone or a telegraph wire, has long since passed out of the experimental stage. One

English inventor, Mr. T. Thorne Baker, has indeed worked out a method of sending photographs by wireless transmission. He is only waiting for wireless telegraphy and telephony to become more efficient and more generally used in order to proceed with the commercial application of his invention. In the meantime, the transmission of photographs over telephone wires, which was first rendered practical by Dr. Korn, of the Munich University, is now being daily carried out between Paris and Monte Carlo. In his improved apparatus, Dr. Korn no longer makes use of the curious element selenium, which allows an electric current to pass through it when it is lighted, and becomes resistent to the passage of electricity when it is in shadow.

In the old selenium method, a transparent photograph on celluloid was attached to a glass cylinder; and, as the cylinder revolved, a narrow and intense beam of light fell upon the photograph. Behind the photograph, and in the hollow of the cylinder, was a reflecting prism, which caught the beam of light when it travelled through the photograph, and projected it on to some crystalline selenium. The selenium was connected with the wire of an ordinary telephone or telegraph, and with the wire from a battery. When the ray of light passed through a whitish part of the photograph, the selenium was affected, and allowed a current from a battery to flow into the telephone wire. But when the ray of light was stopped by a dark place in the moving photograph the selenium was not affected, and no current passed. By moving steadily and continuously, every part of the photograph before the ray of light, all the lights and shadows, were changed into a series of electrical impulses of varying force, with breaks representing the dark parts. This method, however, has been abandoned, because it has been found after some years of experiments that selenium does not give quick and easy results.





PHOTOGRAPHY AS A DETECTIVE OF CRIME

By comparing the photograph of the left-hand finger-print, which appeared on the cashbox, with that on the right, from their record-book, the police were able to identify a burglar.

In the new method, photographs are taken in the afternoon at Monte Carlo and quickly developed and printed on copper plates. These plates are then put into an apparatus, where an electrical needle travels over them. The needle is connected with a battery, and the copper plate is connected with the telephone wire to Paris, and the current is made or broken according to the light and dark places of the picture. For the picture on the copper consists of narrow parallel lines of a material through which an electric current cannot pass; the lines are very thin in the white parts, and broad in the black spaces. It takes but a short time to make a film of this kind by the photo-engraving process. When ready for transmission, the copper film is wrapped around the metal cylinder, and the electric needle is brought to bear against it. As the cylinder turns, the needle runs across the lines of the image. In the whites, represented by the bare copper, it makes a contact, and sends the current in the telephone line. In the blacks, which are formed by the resistent material, the current is cut off.

At the Paris end of the telephone line, the operator wraps a photographic film round a cylinder contained in a dark box. A small, intense ray of light strikes against a hole in the box, but is prevented from entering by a little shutter. This shutter works by electricity, and is directly connected with the telephone line from Monte Carlo. On receiving a message that a photograph is coming over the line, the operator sets the cylinder revolving with its photographic film in the dark box.

A TELEPHOTOGRAPH CAMERA STUDY OF RED DEER IN THEIR NATIVE WILDS IN WINTER

THE HABITS OF THE MOST SHY ANIMALS CAN NOW BE RECORDED FROM A MILE AWAY BY THE CAMERA FITTED WITH A TELESCOPIC APPARATUS
This photograph was taken in the Scottish Highlands by Mr J G Russell. Those on pages [illegible] and [illegible] are from The Romance of Modern Photography by C R Gibson (Seeley & Co)

Then, as the various electrical impulses, representing the white and dark spaces in the picture on the machine at Monte Carlo, travel along the line and reach the electrically worked shutter, the shutter moves up and down accordingly. Thus, the ray of light keeps flashing into the dark box, and printing a little spot on the moving photographic film. When all the film has been covered, it is taken out and developed, and quickly washed and dried, and a half-tone block is made from it. In English illustrated journalism, Mr. Thorne Baker's method, which has much in common with the method of Dr. Korn, has been largely used.

The Failure of the Ordinary Camera to Reproduce Colour

But more widely important than these extraordinary processes of turning a photograph into an electric current, and then retransforming the electric current into a photograph, is the progress that has recently been made in obtaining pictures of things in all their natural colours. As we have remarked, an ordinary photograph is a black-and-white misrepresentation of a scene or an object full of exquisitely graded tints. Pure red colours especially, which are naturally very bright, come out as mere blacknesses, for the reason that the chemicals with which a photographic plate is treated are insensible to the long, red rays of light. Even the green tints of grass and foliage, that often make up the larger part of the colours of a landscape, are not reproduced in proper tone by an ordinary camera. Thus, a common photograph is not even a true black-and-white translation of the world of lovely hues that our eyes perceive.

How Natural Tints are Now Obtained on Special Plates

This defect, however, is now fairly well remedied in the best kinds of modern plates, which are prepared with various dyes that make them sensitive to all colours. Even the invisible long ultra-red rays, at the opposite end of the spectrum, can now be recorded on specially treated films. And photographs of the full range of natural tints have for some time been obtained in large numbers. They have not, however, yet been produced in a general way for commercial purposes,, The coloured picture-postcards and other tinted photographic scenes which are now so common are very far from being examples of photography in natural colours. For the most part, they are ordinary black-and-white reproductions, crudely tinted by some mechanical printing process.

The trouble is that there are two or three methods of photographing things as they really are, in their true tints, but it was for a long time found impossible to make copies of the photographs so obtained. It is easy to take a vast number of copies of an ordinary black-and-white negative. It can be done rapidly by machinery, by bringing a continuous band of sensitive paper above a transparent negative, and flashing a light on the negative and the printing-paper, and then running the paper through a developing and fixing bath. But when a photograph in natural colours is placed above ordinary sensitised printing-paper, so that the light can affect the chemicals with which the paper has been treated, the result is only poor black-and-white reproductions of the coloured image. The fact is, a very special apparatus has to be employed to obtain a complete image of anything, instead of a mere black-and-white diagram of the outlines and masses of the object. Usually some three-colour process is used.

Methods of Reproducing Coloured Photographs More or Less Crude

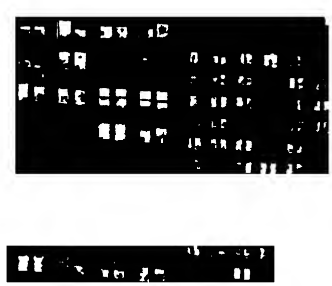
The principle of the three-colour process was announced very clearly by Clerk Maxwell in 1855. "Let a plate of red glass," he said, "be placed before the camera, and an impression taken. The positive of this will be transparent wherever the red light has been abundant in the landscape, and opaque where it has been wanting. Let it now be put in a magic-lantern along with the red glass, and a red picture will be thrown on the screen. Let this operation be repeated with a green and violet glass, and by means of three magic-lanterns let the three images be superimposed on the screen . . . a complete copy of the landscape, as far as visible colour is concerned, will be thrown on the screen. The only apparent difference will be that the copy will be more subdued or less pure in tint than the original."

This suggestion has now been worked out in a three-screen method. But the necessity for taking three separate negatives is obviously a thing to be avoided, if possible. This has been achieved by Dr. John Joly and Mr. J. W. McDonough, by preparing a single plate the surface of which is divided among the three colours. Three lines are ruled on the glass in the three primary colours, and these lines are repeated down the plate. The defect is that they are so coarse as to be obtrusive. Quite recently

after years of work, Mr. J. H. Powrie, of Chicago, has perfected the triple-line method. He uses very fine screens, that photograph the lines on to the plate. First the green lines are photographed and fixed and dyed; the plate is then coated afresh; a new set of lines is photographed upon it and dyed red; and finally another coating is added, and a third set of lines finely adjusted and reproduced and dyed blue. More than six hundred lines to the inch are obtained in this manner.

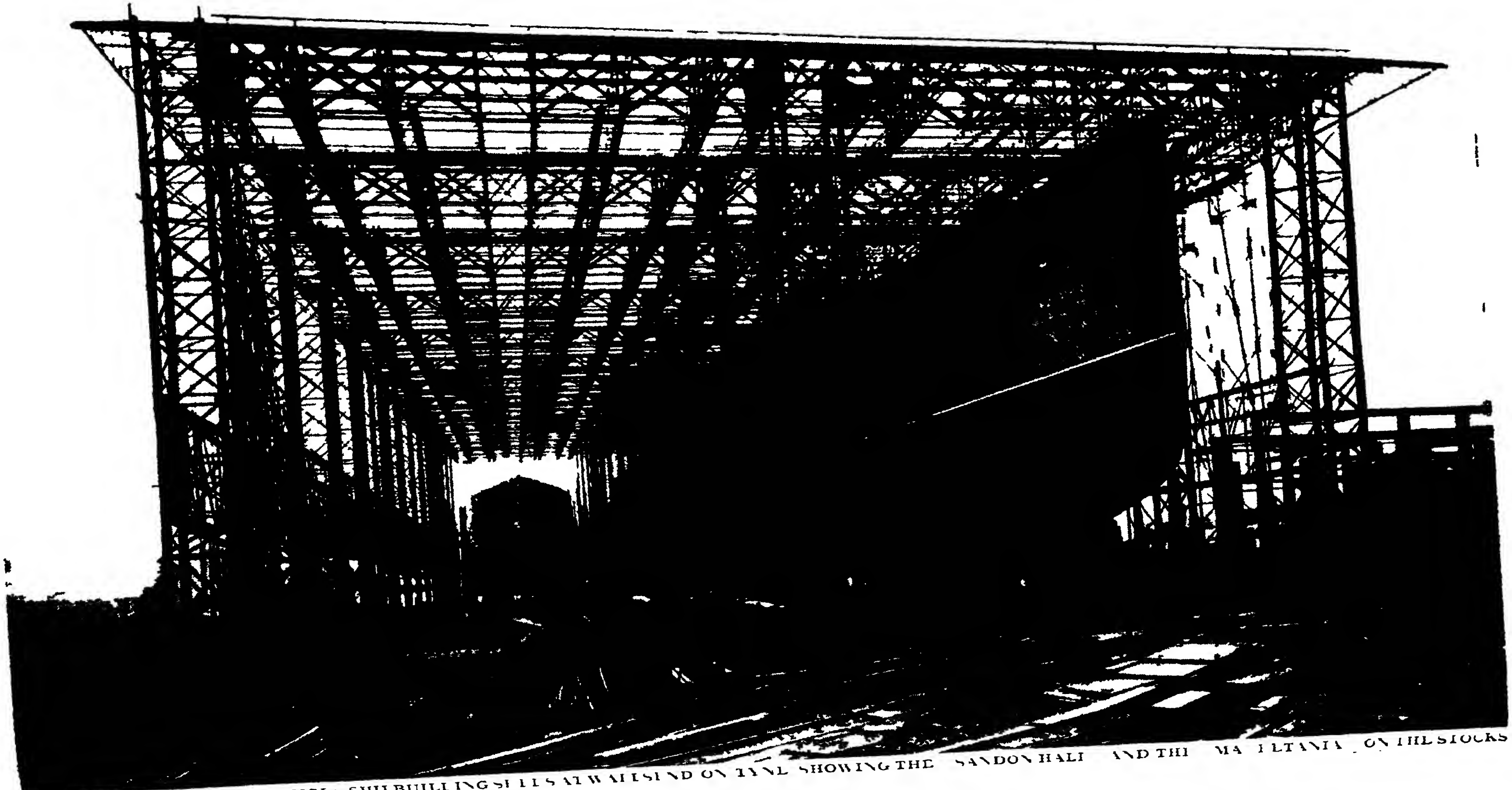
Another ingenious method has been worked out by Messrs. Lumière, of Lyons. A glass plate is coated with a layer of very minute potato-starch grains. The grains are only about one-fifteen-hundredth of an inch in diameter, and they are dyed, in about equal quantities, in violet, green, and orange-red hues. They are then mixed together until they assume a neutral tint, and in this condition they are put on the plate so as to form a very thin but complete coating. A protective waterproof varnish is applied, and on this is spread a film which has been treated with dyes that make it responsive to red, yellow, and green vibrations of light, as well as to blue and violet. Thus the plate is complete in itself—a photographic plate and a colour-screen in one. It is exposed in the camera exactly as usual, except that the glass side of the plate is put towards the lens, so that the light has to pass through the layer of coloured grains before it affects the sensitive film. When the plate is developed and viewed as a transparency, the colours, as well as the form of the original objects, are seen.

All these processes are filter processes; and though some of them are fairly successful, we are inclined to think that an entirely different method, which has lately been perfected by Dr. J. H. Smith, will prove to be the colour-process for which all photographers are eagerly waiting. Dr. Smith begins by dyeing a plate with the three primary colours, which are made so that they are equally bleachable by ordinary daylight. The coloured plate is placed in the camera, and all the colours on it which are not represented in the scene that is being photographed are bleached out. The negative is then developed and fixed; and on placing upon it a specially prepared paper, which is tinted with the same three bleachable primary colours, copies are easily and fairly quickly obtained, by allowing light to fall upon the photograph and print, and bleaching out of the latter the unwanted tints. We understand that the "Uto-colour" process of colour photography, as Dr. Smith names his invention, has lately been tested by many independent experimenters, and found to be the most practical and the most simple of all the methods hitherto devised.



NIGHT PHOTOGRAPHY—THE BUSINESS QUARTERS OF NEW YORK AFTER DARKNESS HAS FALLEN

A STUPENDOUS WORKERS' CELL IN WHICH IS PREPARED THE VOYAGER'S PALATIAL HOME



A GENERAL VIEW OF THE FAMOUS SHIPBUILDING SHEDS AT WALLSEND-ON-TYNE, SHOWING THE "SANDON HALL" AND THE "MAURETANIA" ON THE STOCKS

THE BUILDING OF SHIPS

How the Steel Shell of a Modern Liner is Constructed by Huge Machines

TURNING DISASTER INTO VICTORY

THE greatest shipwrights in the world have only recently ceased to form part of the peoples of the British Empire. They did not, like the shipbuilders of the "Mauretania," Messrs. Swan, Hunter, and Wigham Richardson, use special tensile steel as their material. A few bundles of reed, tied together to form a frail, small raft, enabled the native Tasmanians to achieve the most striking of victories over the wastes of water that long stayed the path of mankind. They were a race of the Old Stone Age, with scarcely any tools, and very little knowledge. Yet on their reed-built rafts they adventured from Asia across the ocean to Australia, and on to Tasmania. For many thousands of years no other people dared to follow them.

The dug-out was discovered in the New Stone Age; the bark canoe followed, and the wooden boat, and the vessel of planks with inserted ribs or decks, but the achievement of the Tasmanians was never equalled. Very likely it was the aggressions of some more warlike tribes that inspired them with the courage to face the unknown Southern waters of the world.

Next to the Tasmanians came the Norwegians, expert designers of swift ships, and discoverers of the New World that the Red Indians seem timorously to have entered on foot over the frozen Bering Straits. All the shipbuilding races between the Tasmanians and the Norwegians were little more than coasting sailors, or, like the Greeks and Romans, cautious voyagers on inland seas.

It was not until the forces of modern civilisation began to stir in the minds of the European nations on the Atlantic seaboard that sufficient progress was made in shipbuilding to endow men with the power of undertaking long ocean voyages in comparative safety. For hundreds of years our islands were sadly behind the chief Continental countries in the craft of the shipwright; only in the Tudor period did we resume the traditions of the Saxon and Danish boatbuilders and seafarers. And our real supremacy in shipbuilding, as distinct from our naval, warlike power, is of strangely recent date.

It is a fairly well-known fact that English naval architects used not to be remarkable for their science of design. They left it to the Portuguese and the Spaniards, and, later, to the French, to strike out new ideas in the form and features of ships, in the days of the timber-built sailing-vessels. It was the sound, honest workmanship of our artisans, and the seamanship and daring of our sailors, that gave us the command of the seas. Our naval architects were little more than the sedulous apes of more enterprising foreign designers, whose ships our seamen captured. So successful was our nation in the numerous wars it waged with Continental Powers that the development of the mercantile marine of these Powers was continually retarded by the operations of our fleet. And the extraordinary expansion of our commerce in the first half of the nineteenth century enabled us to retain in peace the supremacy in merchant shipping that we had partly won in war.

Our position, however, was becoming increasingly difficult to maintain by the middle of the nineteenth century. Our forests of oak-trees were cut down, and our supplies of native ship-timber grew more and more scanty. Thus the material on which our shipwrights relied became more costly and often more defective; and our designers were for the most part content to copy the old, unscientific lines on which ships had been built in the eighteenth century. So large scope and brilliant opportunities existed for the naval architects

and shipbuilders of some well-timbered country. The result was that the American clipper, built on new and faster lines, in a land with an enormous amount of strong, cheap timber, suddenly and completely triumphed over the British-built ship.

It was one of the most rapid and surprising revolutions in industry that ever occurred. There was no new, great force behind it, like the steam-engine in the modern system of manufacture. Simply by means of a finer design, the American naval architect produced a ship of unrivalled speediness, and the American shipwright, with thousands of square miles of ancient forest-land behind him, made the very best of the advantage his designers had won for him. Many British shipbuilding firms went into bankruptcy, and it seemed impossible for our country ever to recover the position it had lost. The cost of imported timber prevented us from competing with the cheaply built American clipper, even when we took to copying the new American designs.

Such was the overwhelming industrial defeat which the genius of our race strangely transformed into one of the most glorious of victories. And so profound was the transformation that for nearly fifty years the American shipbuilder has suffered from the apparent advantages he once enjoyed. Even at the present time, many shipwrights in the United States are still blindly wondering over the cause of the disaster to their merchant marine, and attributing it entirely to the disorders of the Civil War between the Southern and Northern States. Only a few years ago an American journal of good standing pointed out that timber was still much cheaper in America than in Great Britain, and tried to prove that wooden ships were better than any others. The fact is, the receding mirage of the sailing forest keeps some American shipbuilders —after half a century of vain labour—from seeing the vast iron-mines at their feet.

It was the iron and coal mines of Great Britain that enabled our country quickly to retrieve her position in shipbuilding. All that the naval architects of the old school had lost was recovered by a few railway engineers, blacksmiths, and engine-builders. Taking a wrought-iron girder, they covered it in with metal plates, and launched it upon the seas, and there it outsailed and outlasted the fastest and finest wooden-built steamers and wind-jammers. The application of steam-power to marine traffic would not have saved our shipbuilding industries. This salvation was achieved by the invention, first, of the iron ship, and then of the cheaper and stronger steel ship, at a time when we could produce iron and coal more cheaply and more abundantly than any other people.

The defeat of our old-fashioned shipwrights was quickly transformed into a magnificent victory, by reason of the fact that, when the American clipper arrived, all the new materials and new methods necessary for the revolution in shipbuilding had been accumulated and devised. Everything lacking in the shipyards of southern England was ready in the engineering yards of northern Britain. An iron boat was launched on the River Foss, in Yorkshire, in 1776, but the canal-boat "Trial," built in 1787 by a Lancashire iron founder, John Wilkinson, is the first iron vessel of which any description is extant. She was 70 ft. long, constructed of iron plates 5-16 in. thick and put together with rivets like a fire engine boiler. She weighed eight tons, and began her career by carrying twenty-three tons of iron safely to Birmingham. Several boats of the same kind were built and worked on the Severn and the canals of Staffordshire. Then, in 1817, Thomas Wilson, a carpenter in the Clyde Valley, started the huge modern industry of that region by working with a blacksmith on the construction of an iron passenger boat, the "Vulcan." During the making of the ship Wilson was continually jeered at by fellow-workmen and passers-by. " you imagine iron will float ?" he was asked by his deriders. "Pitch your tea-can the canal, and see," replied Wilson.

SYMINGTON'S STEAMBOAT OF 1788 WITH TWO PADDLE-WHEELS IN THE CENTRE.

The "Vulcan" was 61 ft. long, 11 ft. at the widest breadth, and 4½ ft. deep. Built of plates and flat bar frames, the framing and stanchions being forged entirely by hand labour on the anvil, the little iron passenger boat plied on the Forth and Clyde Canal, and stood the test of nearly seventy years' hard service. British shipbuilders, however, were not convinced by these experiments of the

"HAMMERED STEEL" OF MODERN INDUSTRY

Shakespeare found an image of endurance in "antiquities of hammered steel." This is the hammering by a Nasmyth steam-hammer on a big forging, as seen in the shipbuilding of today.

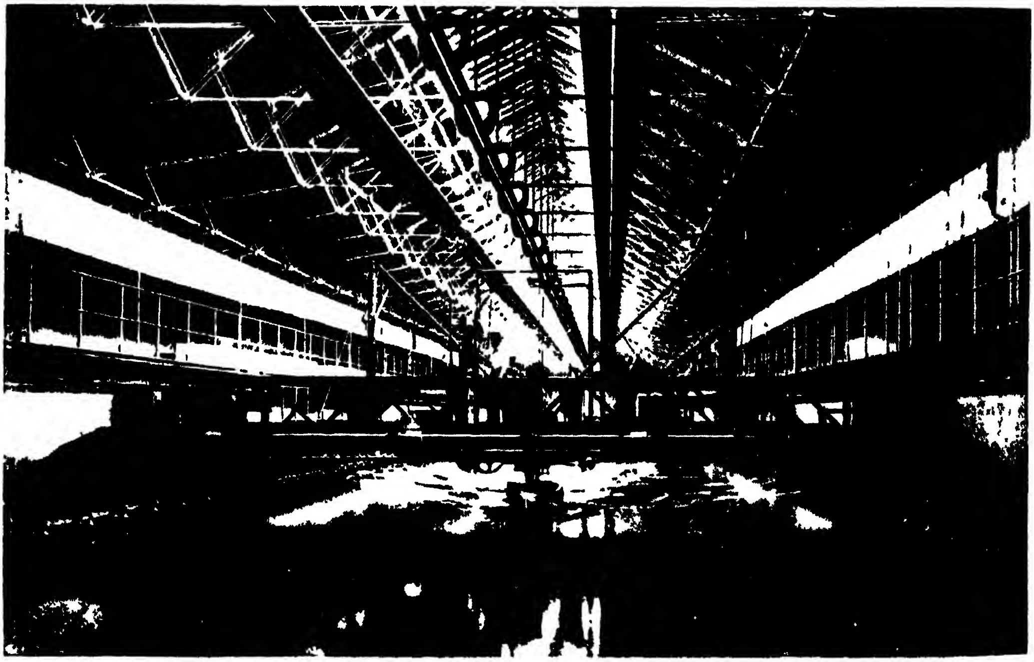
value of iron; and it was a Midland engineer, Aaron Manby, of the Horsley Iron Works, at Tipton, Staffordshire, who had the courage and the skill to plan and build, in 1820, the first iron steamer. Named after her designer, the "Aaron Manby" was 120 ft. long and 18 ft. broad, with engines of 80 horse-power. She was forwarded in pieces to the Surrey Docks, on the Thames, and there put together, and sent with a cargo of iron and linseed to Havre. Ascending the Seine, she steamed to Paris, where her arrival in 1821 caused a great sensation. She was afterwards continuously worked on the Shannon, and her busy life, which has become historical, lasted thirty-four years.

The lasting qualities of these early iron ships are best brought out by comparing them with the powers of endurance of a first-rate wooden vessel of the same period. The timber-built ships of the East India Company, for instance, only made four voyages, occupying eight years. Often they were then unfit for their work; and even when they were thoroughly overhauled and repaired the utmost length of their service was six voyages, of about twelve years. And this was with the gentle, steadying wind-power of sails. The strain of a powerful steam-engine soon knocked a wooden ship to bits. So, although Symington adapted the steam-engine for marine locomotion in 1801, on the "Charlotte Dundas" on the Forth and Clyde Canal, and Fulton used it on the "Clermont," in 1807, on the East Hudson River, directly inspired by the sight of Symington's pioneer experiment, the wooden ship prevented engineers from properly developing the power of the marine steam-engine.

So in 1850 four-fifths of British vessels were still made of wood. Then came the American clipper, also of wood; and the happy result was that by 1860 five-sixths of our important ships were made of iron. It was with this change from wood to iron that our shipbuilding yards and our merchant marine quickly won to that position of supremacy which they both still retain.

Our shipwrights now have behind them fifty years and more of the most varied experience; and if the men continue to take a large view of the continual changes in methods and organisation necessary in a progressive and intensely competitive industry, there seems no reason why our country should not remain far in front of Germany, the United States, and other nations that have, since 1890, begun to compete with us.

There has recently been considerable discontent in some of our shipbuilding centres, owing to the introduction of labour-saving power-tools. But some of these tools were of American or German invention originally; and partly by means of them the great American shipbuilding

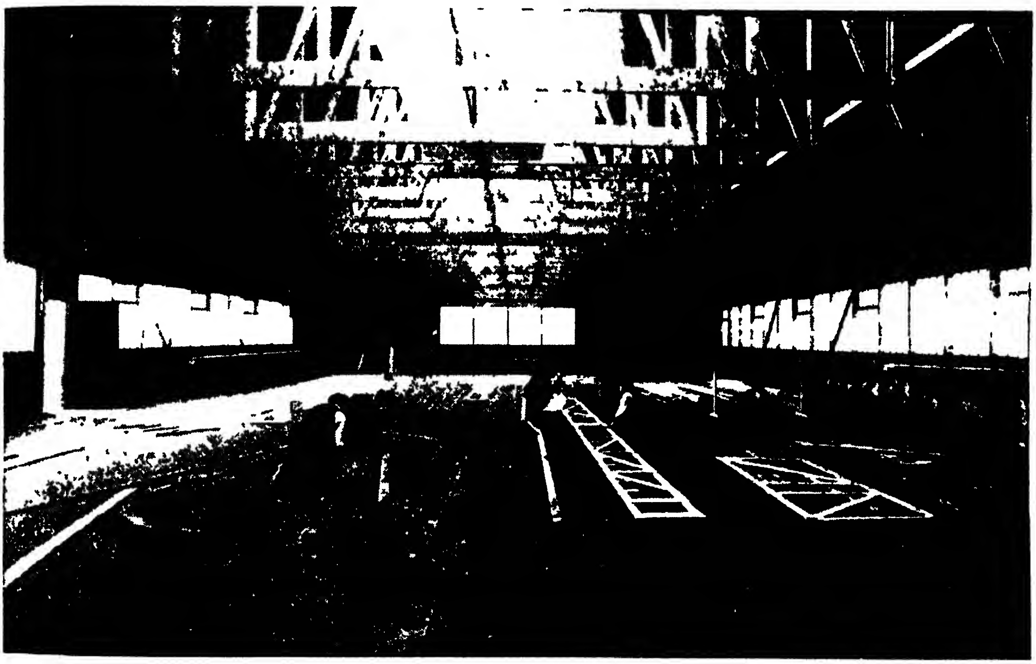


AN EXPERIMENTAL TANK FOR TESTING MODELS OF HIGH-SPEED SHIPS

firms hoped to recover the ground their predecessors lost by keeping to the old-fashioned methods of wooden shipmaking. Thus the directors of our marine engineering works are compelled to profit by every advance made in the use of power-tools, in order to retain the other advantages they have won. Workmen with a skill and ingenuity born of long training and experience may often be reduced, by some new hydraulic or electric or compressed-air device, to the position of machine-tenders. But since the distant days when the hand spinners and weavers tried to prevent labour-saving machinery from being used in their particular industry, it has commonly been found that the field of employment is greatly enlarged by the very inventions that at first seemed to tend to restrict it.

Modern shipbuilding has ever been in a state of continual revolution. There was a large opening for foreign shipwrights in 1875, when our yards were still producing iron ships in great numbers. For in 1873 the French, who have often led the way in the science of shipbuilding, began to use mild steel in the construction of their vessels. Yet some years passed before the use of the new material was sanctioned by Lloyd's, and in 1880 only 35,400 tons of steel shipping were classed on the register. Now the figures for British steel ships are gradually ascending to a million tons. Less than 4000 tons of wood and composite shipping are registered; and scarcely any iron at all. Mild steel and high tensile steel carry nearly all the passengers and cargoes, guns and fighting-crews, that travel about the seas.

For while wrought iron is a cheaper, handier, and safer material for ships than wood, yet mild steel has similar points of superiority to wrought iron. Where a wrought-iron bar or plate will break in a collision or grounding, mild steel will often only bend. In other words, its tensile strength is much greater, and so is its ductility. A steel ship weighing about 8000 tons is as strong as a wrought-iron ship of 10,000 tons. Needing thus less material, it is much cheaper to build; and by reason of its lightness it can carry a heavier cargo, and in that way earn more money for its owner.



PLANNING AN OCEAN LINER ON THE FLAT—LOFTSMEN AT WORK ON THE SCRIEVE-BOARD

At first mild steel cost twice as much as wrought iron. Now, however, it is usually lower in cost than wrought iron. If, in the later 'seventies, the Americans had turned their eyes from the mirage of the forest, and anticipated our shipbuilders in the use of steel, they might again have triumphed over our yards. But happily the Siemens Steel Works, at Landore, in South Wales, were able in 1875 to produce good, mild steel by the open-hearth process; and after acquiring experience of the new

THE LABOURS OF THE SONS OF VULCAN TO WITHSTAND THE VIOLENCE OF FATHER NEPTUNE

A WHITE HOT RIB FOR A MODERN BATTLESHIP BEING BENT INTO SHAPE ON THE BEVELLING SLAB AT THE THAMES IRONWORKS

method at Landore, Mr. James Riley, the first manager of the Steel Company of Scotland, set out to awaken shipbuilders to the great advantages of the novel material. Mr. Riley succeeded in his aim, with the result that the British steel-built ship, light, strong, cheap, safe, swept the seas of the world. Almost every country that needed first-rate merchant ships had to place their orders in the United Kingdom; and, as is well known, a very large number of foreign war-vessels were also constructed by British shipbuilders. Thus, in the lifetime of all but the youngest readers of POPULAR SCIENCE, our shipbuilders achieved a world-wide triumph, equal, if not superior, to the universal victories of our early railway-builders. And quite recently the famous German publicist Count Reventlow sadly remarked that German shipyards could never be worked as cheaply as British yards. "British shipbuilders," he said, in prophetic strain, "will always be in a more favourable position than German shipbuilders, for Great Britain has at command a larger number of efficient shipyards."

And the wonderful thing is that one of the most famous of our yards Harland and Wolff's, at Belfast—continually progresses under the most remarkable disadvantages. Far from being based on any near and cheap source of materials, the Irish yard has to import every ton of coal and metal that it uses. Sheer enterprise and sheer organising power have built up a huge industrial concern, at a spot where all natural conditions, save one, are adverse. The only favourable condition is that Belfast, like most of our shipbuilding centres, is a seaport, to which seaborne material can be cheaply transported, not merely from Great Britain but from such fine mineral centres as Spain and Sweden.

THE MARINE-ENGINE DEPARTMENT OF A LARGE SHIPBUILDING FIRM

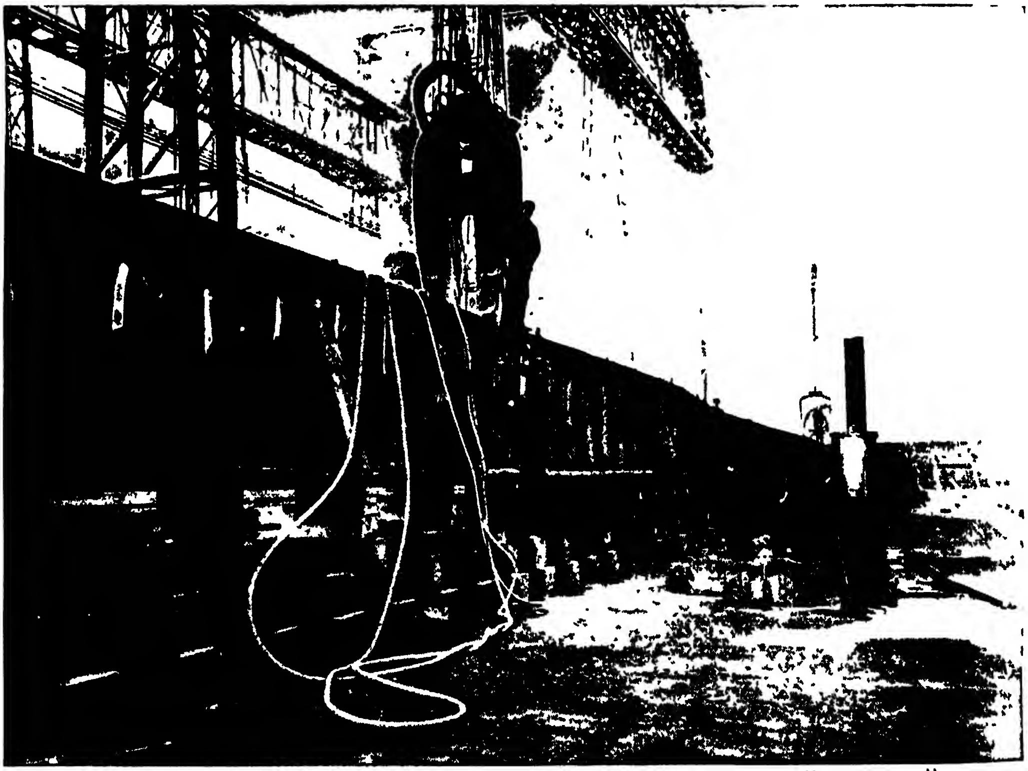
Our chief shipbuilding district, the Clyde, has, on the other hand, been least endowed by Nature to be the mother of big ships. For though it is near to vast stores of coal and ore, it has a shallow and tortuous waterway. But by persistent and constantly increasing dredging the Clydeside men have turned their canal into a channel on which great vessels can be launched.

Since other nations that used largely to depend on our shipyards for both their merchant and warlike fleets have studied

our methods, and taken to building their own ships, another difficulty of an economic nature has been added to the natural disadvantages under which our shipbuilders struggle. For in several countries that would fain compete with us in making and selling ships the wages of skilled workmen are lower than they are in the United Kingdom. Yet the directors of the great industry, on which much of the commercial prosperity and warlike power of our islands depends, still manage on the whole to keep well ahead of all their rivals. For they continue to turn out ships the soundest built in the world, and often the cheapest as well.

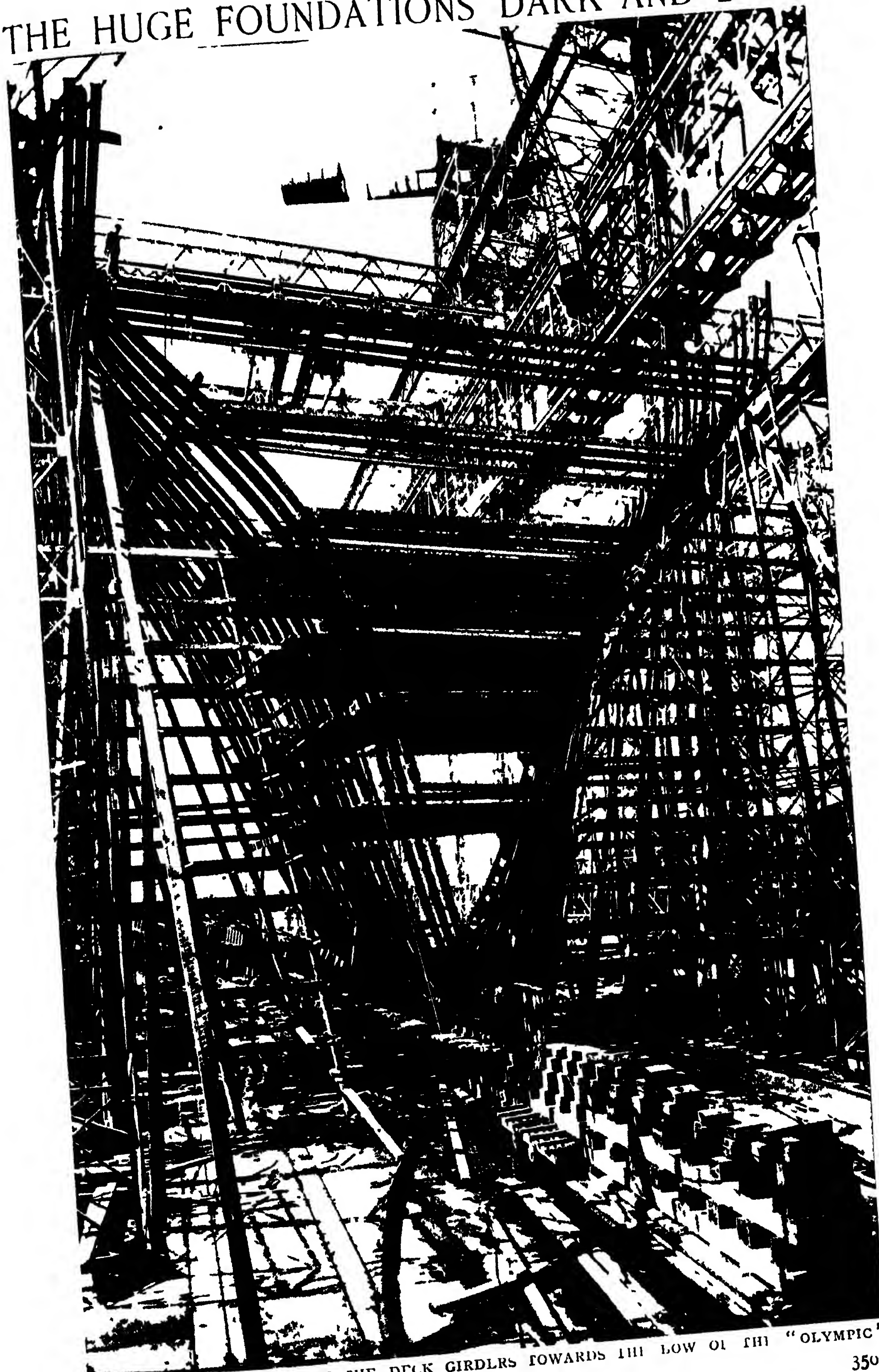
Absolute efficiency in organisation is one of the main factors in this extraordinary industrial success. In our great shipyards science and craftsmanship, enterprise and carefulness, are combined in an incomparable manner. The way in which our Admiralty often draws on private shipbuilding firms for men, like Sir Philip Watts, to design new types of battleships is some evidence of the genius and originating ability of the naval architects who form the backbone of our great marine industry. Our fame in ship design was built up by the disinterested work of Dr. William Froude, the brother of J. A. Froude, the historian, and of W. H. Froude, the Oxford Tractarian. Building a private tank at Torquay in 1870, he experimented with models of varied shapes, until he worked out fully a new theory and practice of naval architecture. He put our country far ahead of other shipbuilding nations by placing British naval design on a large, sound, experimental foundation.

At the present time our Admiralty works out its special problems in design at the Government tank at Haslar, where Mr. R. E. Froude, the son of the greatest of the Froudes, has carried on and developed his father's far-reaching researches. Moreover, many large private firms of British shipbuilders now possess their own experimental tanks. Mr. William Denny, of William Denny and Sons of Dumbarton, for instance, built one at his works in 1882. Much of the success with which our swift battle-cruisers and Atlantic liners have been constructed is founded on experiments made with small models in Government and private tanks. It is by these experiments that our shipyards are often able to send a lower tender for the construction of a new kind of foreign ship than any foreign yard dares to make.



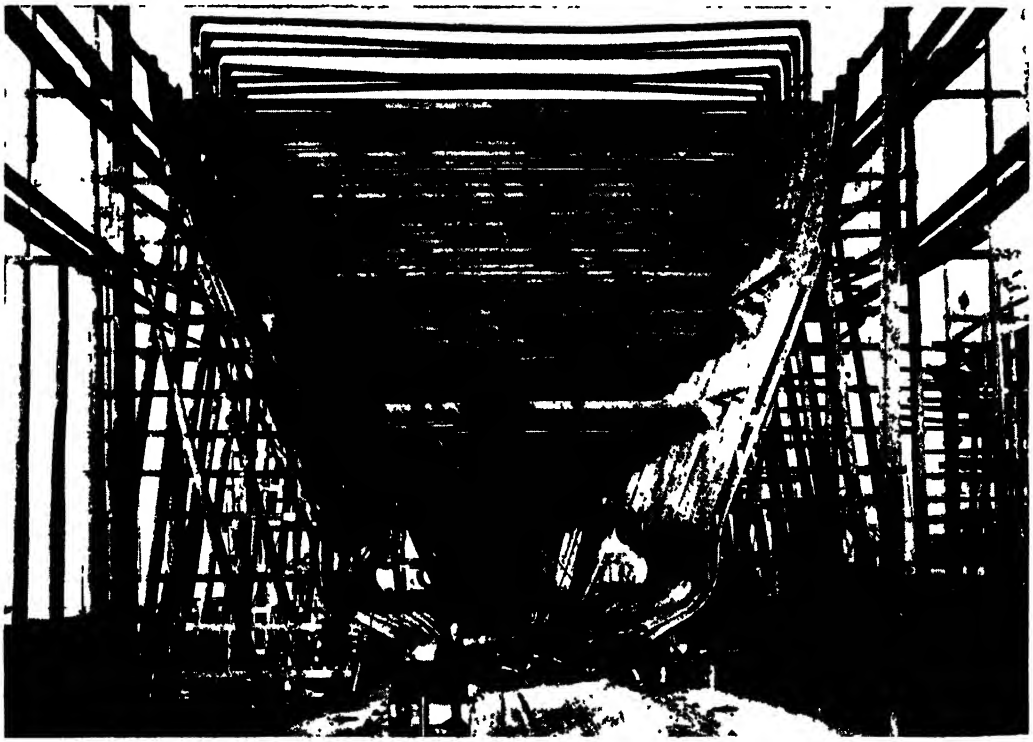
RIVETING MACHINE AT WORK ON THE KEEL-PLATE OF THE "OLYMPIC"

This is largely due to the fact that the



THE FRAMES OR RIBS WITH THE DECK GIRDERS TOWARDS THE BOW OF THE "OLYMPIC"

paper design for a vessel always leaves a considerable margin for waste of material in the actual work of construction. When the owners of a line of steamships have supplied the shipbuilders with a clear idea of the kind of vessel they require, the draughtsman draws out on a small scale the lines on which the ship is to be built. A high-speed liner, for instance, will have different lines from those of a cargo-boat; and an intermediate type of vessel, such as the "Olympic," that carries both passengers and cargo, will, again, be different in design from the "Mauretania," and from a wheat-ship. A vessel designed entirely for means a shipyard with a large, varied, and constant amount of work is often able to save a good deal of money and time in getting its working plans ready. That is another reason why the big and well-established firms can often submit a lower tender than a new and struggling shipyard can. When the main part of the design runs on old and well-tried lines, the shipbuilder of long experience can probably cut his price down to a figure that would mean a heavy loss to a younger firm. For he will not merely save a considerable amount of money in the planning of the ship, but, what is of more importance, he

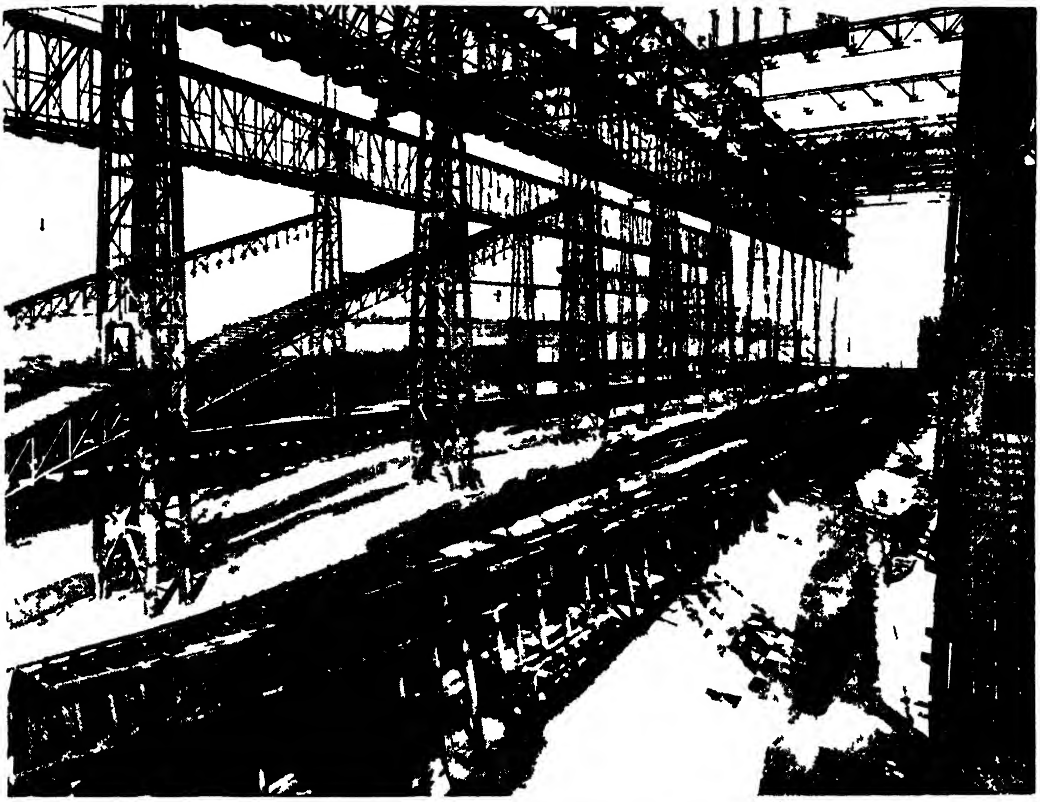


THE STEEL FRAME OF THE "OLYMPIC," SHOWING DECK-GIRDERS AND ADAPTATION FOR PROPELLERS

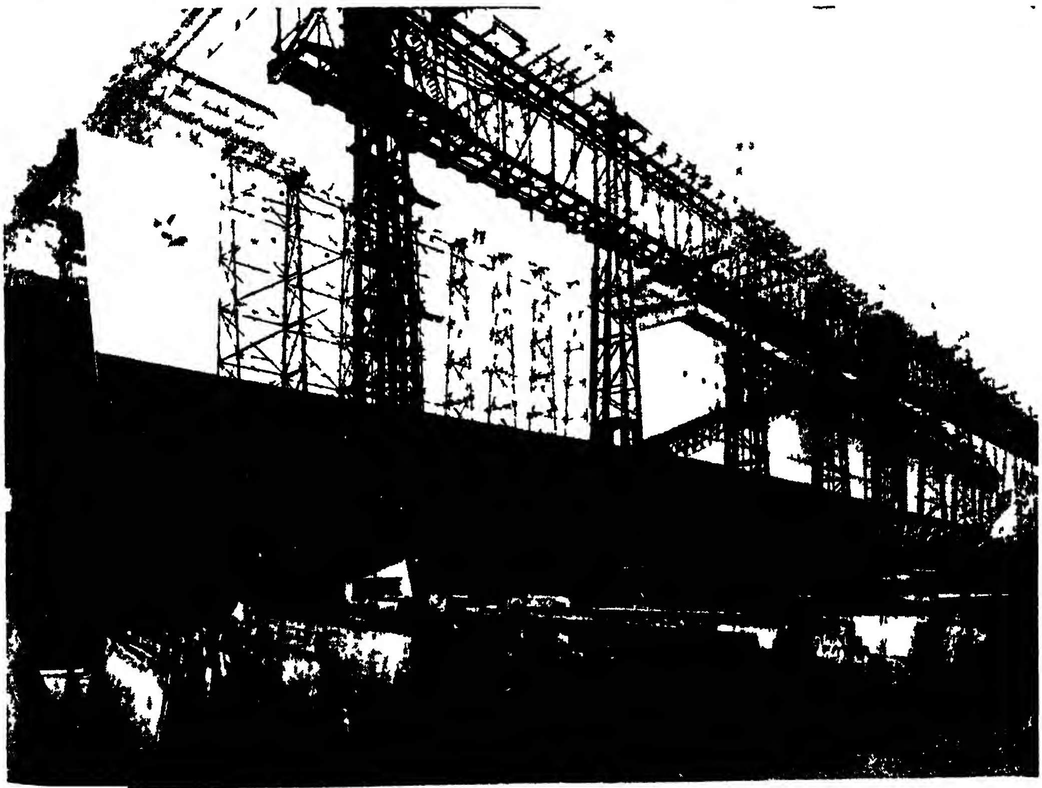
speed has sharp, cutting bows; and if she makes long voyages she requires a vast amount of space for storing coal, so there is little or no room left over for freights. A cargo-boat, on the other hand, has full bows; and as she goes slower, and uses less power in overcoming the resistance of the water, her coal-bunkers are smaller, and there is space in her hold for a great quantity of goods.

The designer works out all these various important factors, and draws his ship accordingly. If there is nothing new and special required in the vessel, he usually takes the drawings of some successful boat built by his firm, and alters them. By this will reduce to the barest minimum the waste of material in building.

The waste occurs when the drawings of the designer are taken to the mould-loft, and there enlarged to the actual size of the vessel. This is done by the loftsman. Taking the floor of the mould-loft as an immense blackboard, he chalks out in mighty lines all the girders, frames, beams, and plates. Everything, down to the rivets and rivet-holes, is drawn full size. There is a sheer plan, showing the water-lines and frame positions throughout the vessel's length. Then the half-breadth plan indicates the deck margin-line and the water-lines from stem to stern, while the body

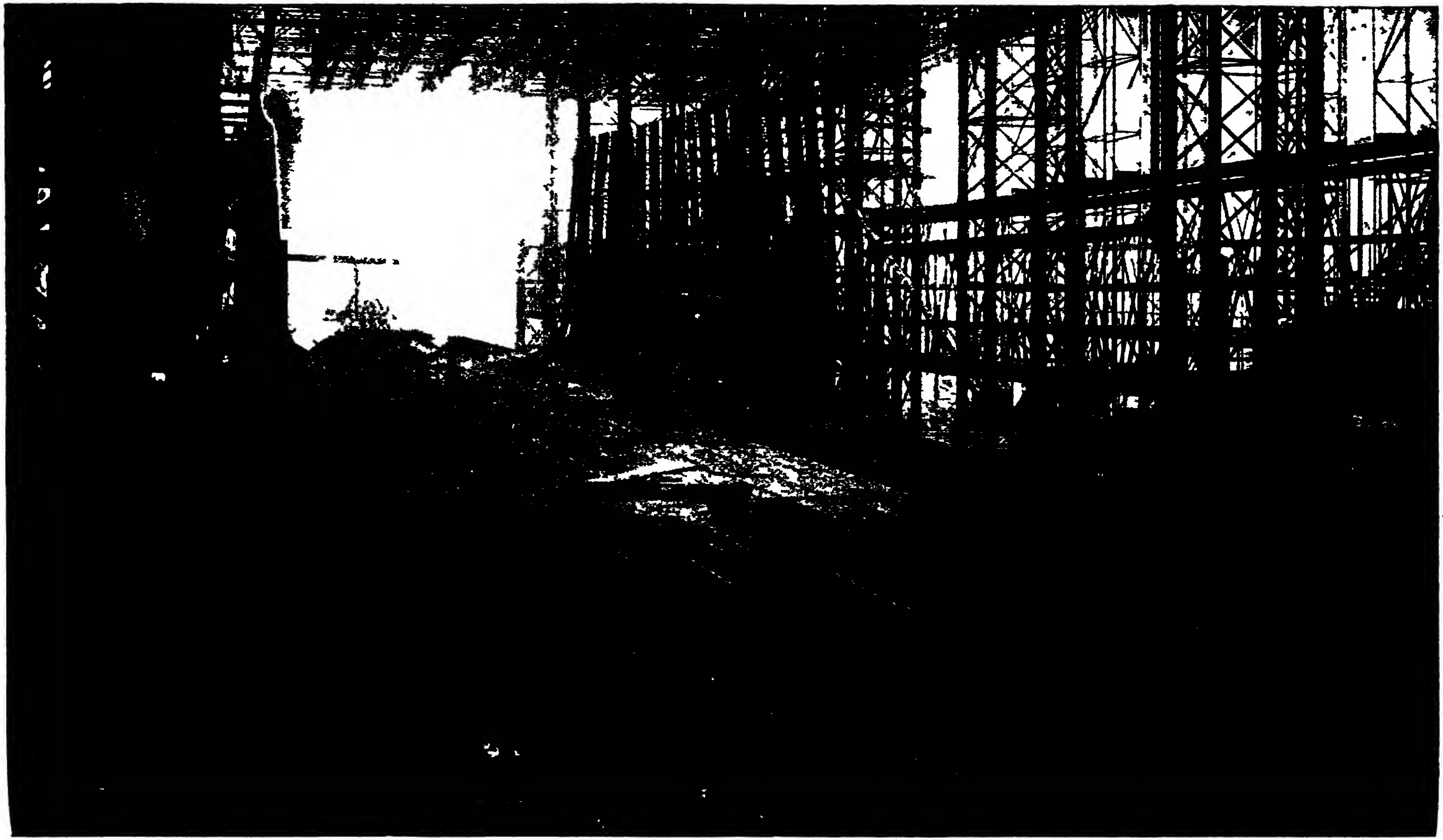


THE LAYING DOWN OF THE DOUBLE BOTTOM OF THE "OLYMPIC"



THE "OLYMPIC" ERECTED AND PAINTED READY FOR HER LAUNCH

FASHIONING WITH PLATE AND GIRDER THE STEEL SHELL OF AN OCEAN GREYHOUND

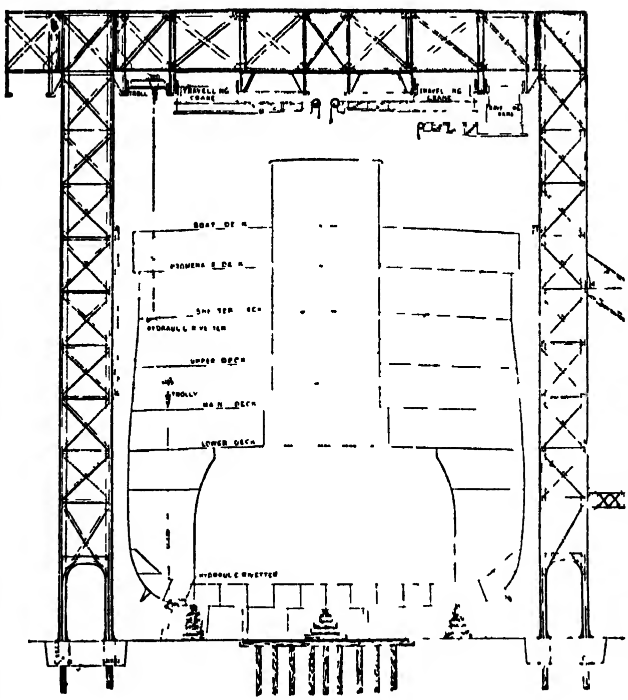


A VIEW LOOKING TOWARDS THE BOWS SHOWING THE CONSTRUCTION OF THE DOUBLE BOTTOM AND THE RIBS OF THE "MAURETANIA"

plan gives the lines of transverse frames, or cross sections, at various stations. And other working plans are necessary to display the entire outer and inner structure of the ship.

After all this huge and yet extremely delicate work of magnifying the original office-designs to full scale, another very important set of plans is prepared.

Close to the particular furnaces at which the men will work is laid an immense floor of pine wood. This floor is called a "scrieve-board." On it is cut, by means of a sharp tool known as a "scrieve-knife," the body-plan of the ship. All the lines and curves are marked on wooden battens, and then cut fairly deeply into the scrieve-board, forming the actual full-sized outlines to which the frame-turners work. In the meantime, the draughtsman orders the materials from the steelworks; and on the skill and care with which he does this the profit of the great shipbuilding operation largely depends. The various plates and bars cannot be ordered of the precise finished dimensions, for these are not known until the parts are actually being placed and fitted in the ship. What is aimed at is to get the rough materials of such a size as will provide just sufficient margin for inaccuracies in the measurements of the drawings. If a part is too small, it will be useless, and serious delay may occur in procuring another part. If, on the other hand, the ordered dimensions are too big, the surplus material will be troublesome to remove, and, as scrap steel, it will only fetch a third of its original cost.



SECTION THROUGH A SHIPBUILDING SHED AND THE TIMBER PILING UNDERNEATH THE SHIP

The waste may be lessened by obtaining accurate measurements from the mould-loft plans; but usually, where the ship has to be built at great speed, the material must be ordered from the draughtsman's small-scale designs. About ten per cent. of wastage is the usual allowance. But where a ship is being constructed on old lines, all the full-sized measurements can be seen on the battens formerly used in cutting the plans on the scrieve-board. In this way wastage of material can be cut down by very accurate calculations on the part of the draughtsman, with the result that the second ship costs less to build.

We have gone at some length into the laborious and careful way in which the drawings of a ship are made and enlarged and scrieved, for this is the most important part of shipbuilding. A ship is an idea before it is a fact; and on the clarity, judgment, and precision with which this idea is conceived and worked out depends the success of the shipwrights. Picturesque and spectacular as is the aspect of a great shipbuilding yard, with great cranes travelling, like strange animals, from the towering webs of steel scaffolding, while below the huge skeleton of some yet unborn ship sprawls on the keel-blocks and lifts up her gaunt, enormous naked ribs, and the tiny, ant-like figures of the workmen run to and from the furnaces, or wait by the quiet but terrific hydraulic machines that bend or bite large holes out of the cold, heavy steel plates thrust by other mechanisms into their jaws; yet the unseen intellectual power behind this impressive and extraordinary scene is the thing to wonder at.

All the marvels of modern machinery, driven by steam, electricity, compressed air, and water, are strikingly displayed in a shipbuilding yard. But at the back of it all is the daring, ingenious human mind, forging, by means of enormous slaves of steel, the instruments of power that make the stormy spaces of the great oceans almost as safe a

path as a Continental railway track. By standing a steel bridge upright on its end, the modern engineer constructs a sky-scraper; by keeping the bridge stretched out lengthwise, and making one end smaller, and covering the girders and frames with steel plates, he builds a modern big ship.

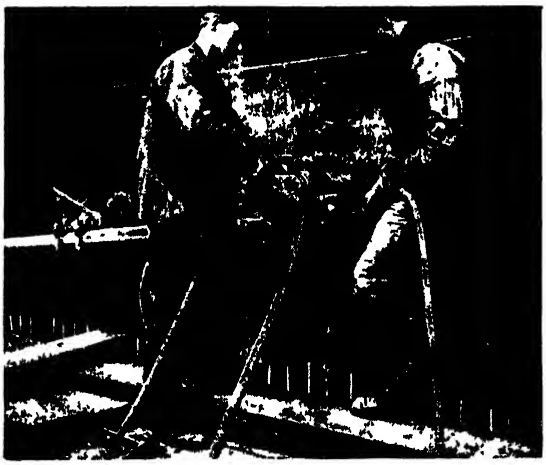
The main lines of construction are as simple as they are strong. They consist of girder forms that extend from stem to stern and ensure lengthwise strength, and transverse frames that cross the lengthwise girders at right angles and afford lateral strength. In warships of considerable size, the lengthwise girders are the most important part, and the steel ribs are slighter—this is the longitudinal system of shipbuilding. In many merchant ships the lengthwise girders are somewhat less powerful, but the ribs are thicker and more closely set together—this may be termed the transverse system. It is more economical in building, and it gives strength to that part of a ship where the heavy cargo is carried.

On the other hand, a ship constructed on the longitudinal system is the stronger of the two, especially if unusual care is given to attaching the rather light ribs in an exceedingly firm manner to the lengthwise girders and crossbeams. And though the "Mauretania" and the "Lusitania" were not built like battle-cruisers, on the longitudinal method of framing, the new high tensile steel, which is from a fifth to nearly a half stronger than ordinary mild steel, was employed in all parts of their hulls that had to stand the greatest strains.

In the ordinary way of shipbuilding, the task of the workmen is comparatively easy at the beginning. It is all straight work. Massive slabs of timber are sunk perhaps 40 feet in the ground, and down the centre of the berth thus prepared small portable baulks of wood are placed, forming piles from 4 ft. to 5 ft. high. These timber piles are called "keel-blocks." Upon them the keel is built, as shown on page 3611.

All the work of building the keel and other lengthwise steel structures is laborious and important, but it is similar to that of ordinary girder construction. More interesting is the task of the frame squads, who curve and shape the frames that form the ribs of the ship. Each squad usually consists of about six men, assisted by a number of labourers. They work on a solid floor, made of cast iron, and known as the bending blocks. The bending blocks are as close as possible to the furnaces and near to the scrieve-board and punching machines. The work of the squad begins with punching rivet-holes in the frame-bars. They often do this at a speed of fifty holes a minute with the punching-machine, the very heavy frames being hung from a crane.

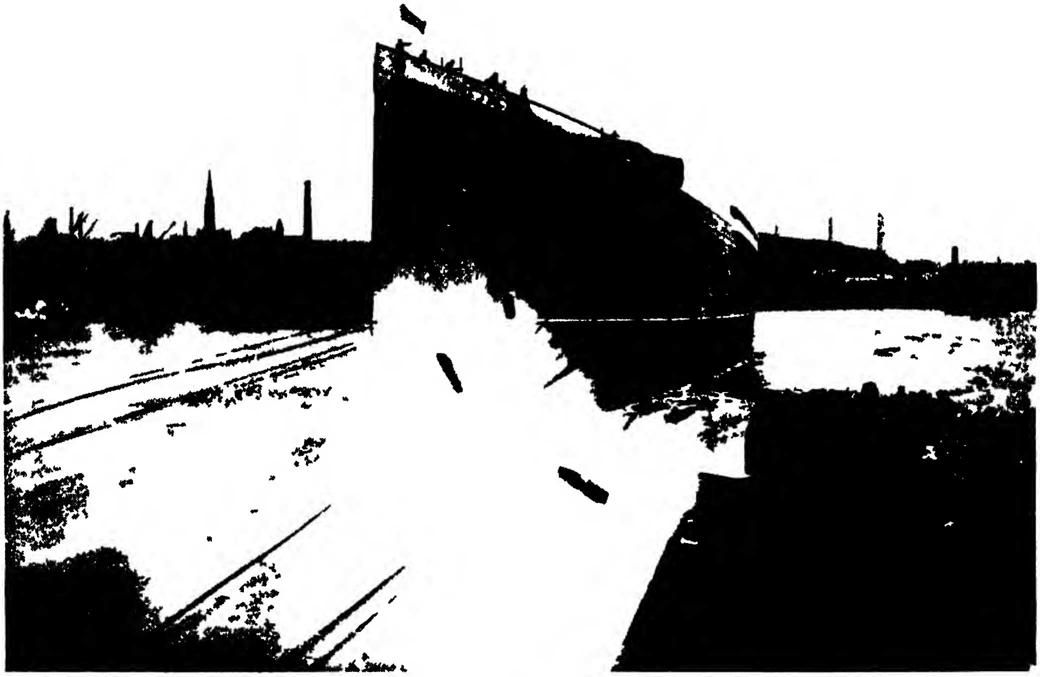
One of the men then takes a set-iron, or pattern, and places it on the scrieve-board where it is hammered to the exact curve shown in the drawing of the frame The set iron is next laid on the bending blocks and fixed down by clamps inserted in the holes with which the iron floor is regularly fitted. Then the frame-bar is drawn red-hot from the furnace on to the slabs, and placed beside the set iron, and clamped down; and there, by means of levers and crowbars, it is forced against the set-iron and partly bent and partly hammered to the exact curve required. Sometimes a small portable hydraulic ram is employed in the final operation on the frame. The beams are prepared in a similar manner close to the furnace.


RIVETING SHELL-PLATES ON THE SIDES OF SHIP BY A PNEUMATIC TOOL

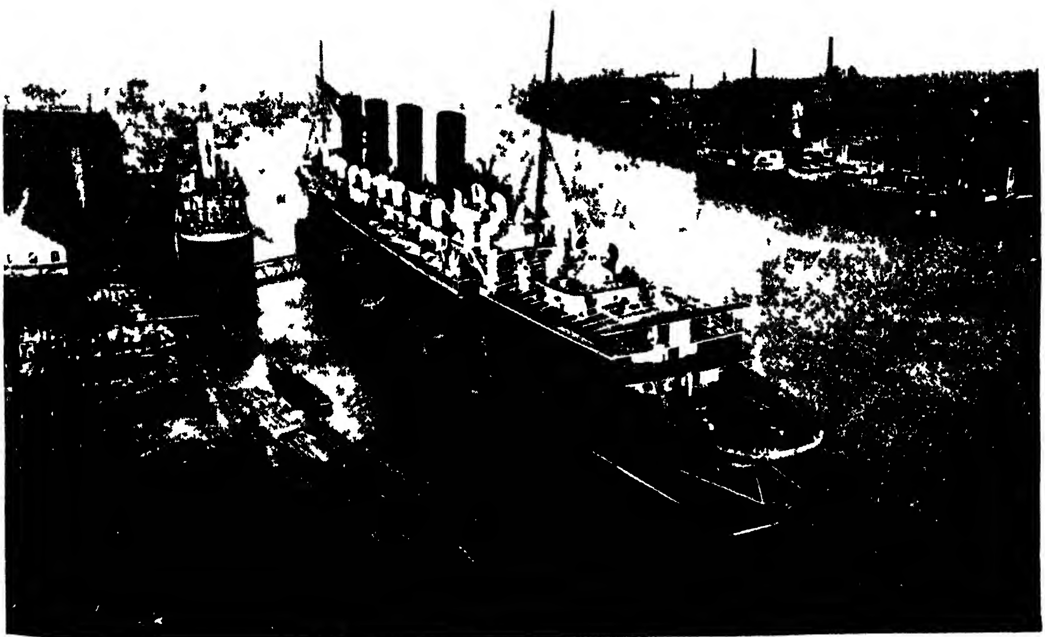
As the ribs are got ready, they are brought to the building berth, and erected each into its appointed place, at right angles to the keelson. The beams are fixed overhead to hold the outer framework in shape, while wooden ribands are temporarily bolted to the frames to "fair" the whole structure to its correct shape. The bulkheads, or partitions that divide the ship into water-tight compartments, are also brought up and adjusted, increasing the strength and rigidity of the huge steel skeleton.

The massive stern-frame of cast or forged iron or steel, on which the rudder and the propeller brackets depend, is set in position

THE WORLD'S FASTEST LINER LAUNCHED

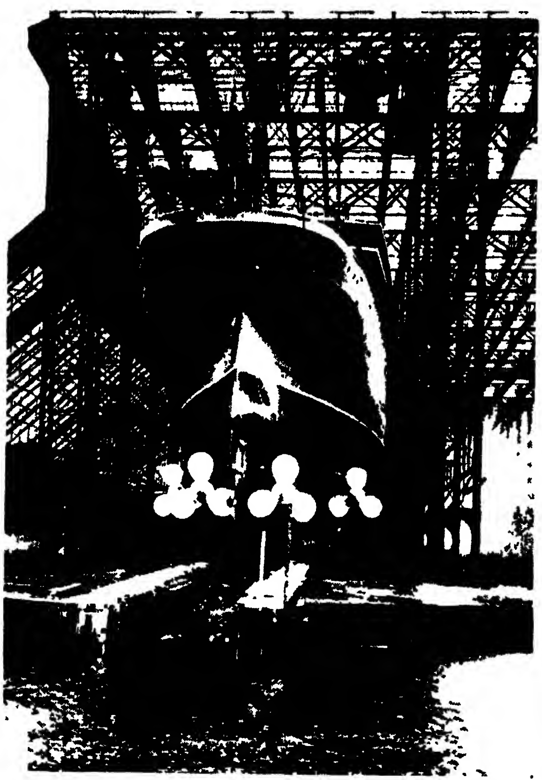


THE LAUNCH OF THE "MAURITANIA" FROM THE SHIPYARD INTO THE TYNE



THE "MAURITANIA" RECEIVING FINISHING TOUCHES AS SHE LIES OFF THE SHIPYARD

by the giant cranes, and the steel stem is upreared into its place. All this time work in various other directions is going on briskly. The deck planks are being got ready; and in the joiners' and cabinet-makers' shops the cabin and other woodwork is being fashioned. The boats are in course of construction, and the steel masts and spars are taking shape in the sheds and spaces set apart for this work. Blacksmiths, brassworkers, plumbers, and other craftsmen are busy over the fittings. The foundries and engine and boiler shops are putting together the great mass of complicated machinery that will drive the vessel. And far away, in London, in the case of great passenger liners, perhaps, artists are designing schemes of decoration, and mechanics elsewhere are labouring at refrigerating machines, electric dynamos for lighting and ventilating purposes, and the furniture of the luxurious travelling town that is to be placed within the mighty framework of toughened steel.



"MAURETANIA" ON THE STOCKS

In the machine sheds the immense plates of strong, elastic metal have already been planed at the edge by gigantic planing-machines, and rolled in mighty rollers to a uniform curve. Plates of cold steel, an inch in thickness, and of great extent, are carried by cranes to the various shaping machines, and manipulated with marvellous ease and rapidity. Punching and shearing are done by electrically worked mechanisms, that cut through the steel plates as if they were cheese. The most striking of all the gigantic slaves of the shipbuilder are the quiet hydraulic machines that with a single pressure cut out of the plates oval pieces, nearly two feet across, to serve as manholes in the lengthwise girders and floors of the vast expanse of the double bottom.

The shell-plates that form the skin of the ship are worked by means of templates, or wooden patterns. The light patterns are fitted against the frames, and marked for shaping and riveting. Then the long, heavy, steel plates are bent and holed according to the wooden pattern, and swung by cranes to their place and temporarily bolted in position, and then riveted together.

In the best kind of warship construction each band or strake of plates, that runs lengthwise along the hull, is "butted." That is to say, where one plate joins another a backing of steel is inserted and strongly riveted on to the two plates. But in passenger and cargo vessels the plates are made to overlap, and the overlapping edges are riveted together, thus saving a good deal of material and weight and half the amount of riveting. Often, owing to the projecting plate ends, a lap-riveted hull goes through the water with more friction, and thus lessens the speed of a ship.

The riveting of a steel vessel is an affair of vital importance. No matter how strong may be the material of the girders, frames, beams, and plates of a ship, if the rivets are weak the entire structure is weak. So the riveting squads of a shipbuilding yard are generally the men whose qualities of work count most when a vessel collides, or strikes a rock or iceberg, or runs aground. In manual riveting a squad consists of two hammer-men, a holder-up, and a heater. The heater is the youngest member of the squad, and he heats the rivets to a white glow in a portable hearth, and passes them on to the holder-up, who, in the case of shell-work, is inside the hull. The holder-up inserts the point of the incandescent rivet through the empty hole, and holds a heavy hammer against the rivet-head

while the two hammer-men outside, with quick, regular, skilful blows, knock down the rivet-point, and spread it into the hole, leaving but the suggestion of a projection on the surface of the shell.

Some modern power-riveters weigh five and a half tons, and have jaws seven feet wide. They are sometimes carried on huge steel gantries, that span the place where the ship is being built, and travel by electric power up and down the length of the berths. By these gantries there are huge power-tools for punching, drilling, and riveting, and furnaces for heating the rivets, and cranes for lifting the vast sections of shell-plating. Or, instead of moving gantries, a high overhead electric railway, with as many as nine tracks, is erected on great steel columns and girders, for handling the machine tools and the heavy materials for the construction of the ship.

After the rivets have been forced in by hydraulic or pneumatic power, the caulkers make the plating edges and backings water-tight by hammering the edge of one thickness close down to the surface of the other by means of a compressed-air tool. The shell is then painted, to resist the corrosive action of the sea-water. With the completion of the steel shell, and the concurrent progress in deck-plating and deck-fitting and other features of the structure, the vessel is ready for launching. The launching structure is in three parts: the ground-ways, that remain stationary; the sliding ways, that go into the water with the ship; and the cradles, that rest on the sliding ways and support the ends of the vessel. Until the moment of launching, the sliding ways are locked to the ground-ways by a piece of hard wood or steel, termed a dagger; and in the case of a big ship a few of the keel-blocks and other supports are retained, and removed at the last moment. Then come the signals from the shipyard manager: "All clear!" and "Down dagger!" Away the dagger is knocked, and slowly the mighty hull stirs, and the bottle of christening wine is broken on her bows as she goes down to the sea. The critical period of a launch occurs when half the length of the ship has passed over the ground-ways. For if the immersion of the after-part is insufficient to buoy it up, the entire hull may pivot about the ends of the ground-ways, and the ship may be badly injured.

But accidents of this kind are now rare. Helped at need by hydraulic rams, the new leviathan of the deep glides into the water, where her timber cradle floats asunder. The ship is then brought alongside the engine-works quay, and the huge boilers, engines, and accessory parts are hoisted on board by powerful cranes, some of which handle 150 tons of steelwork with exquisite precision.

FLOATING CRANE PLACING A BOILER ON BOARD THE "MAURETANIA" AFTER LAUNCHING

The iron deck-houses and casings, that were left unfastened so that the propelling machinery could be lifted in, are fixed down, and much of the deckwork and interior fittings is installed.

Piece by piece the engines are re-erected on their seatings, all pipe connections are accurately made, the huge funnels are hoisted and riveted down. The engines are turned round under steam at the moorings, and any imperfections are rectified. After the painters, upholsterers, electricians, and plumbers have completely finished the details of the floating palace, the anxious designer of the ship quickly knows if he has planned everything rightly. For a series of trial runs is made, in which coal consumption, speed, and carrying capability are exactly measured. These trials and investigations of the abilities of the ship, at various powers and rates of revolution, provide the designer with his most valuable information. They extend and correct the knowledge obtained with small models in experimental tanks, and thus often enable a keenly observant man to discern where the next advance in shipbuilding science can be effected.

CO-OPERATION AN AID TO DISTRIBUTION

PACKING BISCUITS IN ONE OF THE DEPARTMENTS OF A WHOLESALE CO-OPERATIVE SOCIETY

THE CENTRAL PREMISES OF THE WHOLESALE CO-OPERATIVE SOCIETY AT MANCHESTER

THE SHIRT-MAKING DEPARTMENT IN A LARGE CO-OPERATIVE SOCIETY'S FACTORY

THE RISE OF CO-OPERATION

The Reconciliation of Individual Enterprise with Co-Operative Effort in the Production of Wealth

SOCIETY AS A CO-OPERATIVE FRAMEWORK

Competition is as instinctive in man as self-preservation, of which, indeed, it may be regarded as a phase. It is an instinct which throughout the animated world leads individuals to wage their chief contest with their own kind in the struggle for existence. In some sort it will undoubtedly survive in human society; and the working out of the form or forms of its continuance creates some intensely interesting problems.

In the field of economics competition has been defined as the unrestricted exercise of the self-interest of the individual, but in this strict sense competition can scarcely be said to exist at all, save where established by State law, or when it is the exercise of a supreme individual gift, as in the case of a highly talented artist.

Under a system of unrestricted and unregulated competition the life of man would be a fierce struggle between individuals each desirous of securing the largest possible share of the product of human activity; and the mental picture that is conjured up by the words is an exceedingly unpleasant one. In all ages and in all countries competition has been regulated more or less by custom largely springing from human affection. Custom in particular plays a part in the purchase of labour, in which regard it has always been a powerful safeguard for the weak.

The customs and usages which arise in all countries had their basis in rude justice. An excellent illustration of the manner in which custom conquers competition is the métayer system of land tenure which exists in Italy and elsewhere, by virtue of which the land proprietor lets a farm to a family, usually supplying the necessary agricultural stock, and takes as rent half of the produce of the farm, whatever that produce may amount to. Where this custom is established, no one dreams of either offering or accepting any different terms, no matter how the price of produce may vary, and no matter whether the land yields much or little. That means the absolute elimination of competition by custom.

Thus also it is with the customary wage. A builder in a certain district would not dream of offering a bricklayer less than the established wage of the district. The honour of custom would prevent him from saying to a bricklayer: "You are out of work. I will take you on if you will take so much an hour"—naming a sum less than the established rate. It is true that there are trades in which, at least in some districts, no customary rate has been arrived at, and where sweating exists, but in the general case the employer does not depart from the customary wage, although we often find him refusing a demand for an advance upon the customary wage.

A very striking instance of the elimination of competition is to be found in the honourable customs of some of the professions. The charges of solicitors, doctors, and architects, for example, are invariably so regulated. If one solicitor earns more than another, it is not because he charges more for consultation or for writing a letter, but because he has more clients; and the same is true of the physician. Architects, again, have a scale of charges, and the most talented architect will not charge you more than the recognised professional fee, although his work may be ten times as valuable as that of a fifth-rate man. Curiously, with barristers, a different custom obtains; and usually, as a barrister's reputation increases he raises his charge, until we hear of a brief being marked with fifty, a hundred, or even a thousand or more guineas. In the ordinary way the custom obtaining in the medical profession is one which illustrates how powerful usage may become. It is

customary for medical men to charge patients fees which vary with their social status, so that they obtain much from the rich and little from the poor. Competition is, for practical purposes, eliminated as to price, although it exists, of course, with regard to the amount of work to be obtained. The modifications of pure competition, indeed, are so many that it is plain the higher qualities of man have largely triumphed over self-interest. The Economic Man rarely or never exists.

Will the Desire to Excel be Weakened if Competition is Modified?

Nevertheless, the circumstances of a complex society which, as we have before remarked, often hide the real character of operations even from those who engage in them, make it difficult for individuals to discern the play of economic forces, and to understand when competition has proceeded to lengths which are socially undesirable. The customs of a simple community, in which everyone is acquainted with everyone else, and feels honourably bound to deal fairly with everyone else, may be altogether erased in a complex civilisation in which next-door neighbours do not know each other's names, and in which the ties of human affection are difficult to maintain.

Educationalists have sometimes complained that the spirit of competition is instilled into children at school, and that the whole tendency of our method of training is to imbue the young with the idea of "getting on," that "getting on" being an exercise in the art of climbing on the shoulders of other people. Others, again, contend that if the spirit of emulation were not instilled into the child progress would cease, since no one would desire to excel. It does not follow, however, that the desire to excel may not exist together with a recognition of the folly of unrestricted competition.

The Advantages of Free Competition to the Consumer

It is conceivable that a boy could without much difficulty be trained to believe that civilisation might be run on the same principles which obtain in the case of a cricket eleven or of a national army.

Turning to competitive industry, we see it carried on by a very considerable number of capitalists, each intent upon supplying as large a part of the available market as possible. What is the available market? As far as the home market is concerned, it consists of the power possessed by the nation at large to purchase the particular commodity. At any given moment that power is definitely limited, not by desire but by necessity. The competitive capitalists each seek to secure orders in this limited market, which, taken as a whole, they have no means of measuring. There is both good and evil in the position which obtains. Each of the masters, in his desire to secure a hold on the market, does his best to attract customers by making his goods attractive, and by under-cutting prices. In pursuance of these objects, he seeks to apply better processes and inventions and the desire to excel his competitors is strong in him. These things make for the benefit of the consumer of the commodity in question, who sees a number of men fighting together for the privilege of serving him. In this struggle for trade, fine qualities may be evolved, and, other things being equal, those best fitted to supply the market will triumph. By a process of natural selection the unfit capitalists are eliminated, and the trade comes to be carried on by a group of men qualified for the task.

Disadvantages that Accompany the Process of Unlimited Competition

On the other hand, great evils accompany the process. If there are, say, a hundred capitalists in an industry competing with each other, the chief difficulty of any one of them is not to make goods but to sell the goods that he has made in competition with his ninety-nine fellows. The crux of the business is not the making of goods, but the selling of goods. The chief concern of the manufacturer is not with the technical side of his business, but with the commercial side. Under such circumstances, striving becomes more a matter of striving for the market than of striving to produce better goods. Indeed, the striving to produce better goods is apt to be regarded as a subordinate matter. Moreover, if there is a considerable number of capitalists engaged in a limited trade, then it is obvious that they cannot all be in the possession of large sums of capital; and if large sums of capital are required to conduct the business economically, then the most economic working of the business must inevitably fail.

Again, the maintenance of a hundred separate businesses calls for expenditures which, regarding the trade as a whole, are obviously wasteful. Each of the hundred firms must necessarily have separate works, separate warehouses, separate offices,

separate managers, separate sets of clerks, separate staffs of travellers, separate accounts, separate advertisements, and so forth. If the trade has a hundred separate masters, there must be borne upon it as a whole the cost of maintaining thousands, or tens of thousands, of employees who are unnecessary from the point of view of the trade considered as a whole. Bearing such unnecessary costs must largely counterbalance, or more than counterbalance, any cutting of prices which is effected by the competitive process; or, to put it another way, none of the capitalists can afford to cut his prices below a point which will enable him to maintain the necessary appurtenances of an individual business.

The Puzzle of How to Find Out what it is Best to Buy

Many other considerations arise which make the competitive system anything but advantageous to the consumer. Even the common necessaries of life - corn, meat, etc.- may be subjected to manipulations of price which are an abuse of the competitive system. With regard to other commodities, it often becomes exceedingly difficult to buy well or wisely. In the purchase of such articles as cycles, boots, hats, pianofortes, kitchen ranges, baths, etc., the man in the street is puzzled to know where to buy for the best. So far from competition helping him, it confuses him by presenting to his mind such a mass of advertising matter and contradictory statements that it is next to impossible for him to arrive at a sound judgment. One feels exceedingly sorry, for example, for a man who, without good advice, sets out to buy a certain article sold by ironmongers. All he knows is that there are a number of machines to be had, and the maker of each of them alleges that his is better than the others. He buys, but it is ten to one that he does not buy the best value to be had in the market.

Directions in which Competition Has Been Eliminated Already

Indeed, the market in any particular commodity often presents itself to the buyer in very much the same way as the street signs in a crowded thoroughfare. The object of a street sign is to attract attention. When, however, in a long thoroughfare of tall business premises of several floors, each member of each of the several floors living at each number displays a sign which endeavours to outbid all the others in effectiveness, the result is so much confusion that a stranger in the thoroughfare is hard put to it to distinguish what he has come to find. The signs defeat their primary object, and bewilder instead of aiding the wayfarer. This is equally true of all modern advertising.

These and other considerations which might be named are undoubtedly becoming increasingly recognised by practical business men. In so far as competition is harmful or uneconomic it must in the long run come to be eliminated, which is not by any means the same thing as saying that human competition must end. If we consider society, with its professions, trades and industries as it now exists, we cannot but be struck with the degree of elimination of competition which has already taken place. As to those industries which involve the use of pipes or conduits, or lines, or wires, or tracks, it is so easy to see that competition is an absurdity that for all practical purposes civilisation by common consent has abolished competition in them in all countries.

The Necessary Return of Monopoly into Some Modern Businesses

Railways, canals, tramways, telegraphs, telephones, sewers, water supply, roadmaking, gas supply, and electricity supply are everywhere carried on on a monopolistic or quasi-monopolistic basis. Sometimes the industry is privately owned; sometimes it is nationally owned; sometimes, again, it is controlled by a municipality or other local authority; in every case it is a monopoly or almost a monopoly. The exceptions are so few as to be negligible, and where they obtain they point to a blindness which can only be termed extraordinary.

What would be said if, in a single street, two or more separate surface sewers were constructed to carry away the rain-water which could be easily dealt with by one? What should we think of the spectacle of two or more competitive tramway systems lining a thoroughfare with their unnecessary rails in order to carry on an unnecessary competition? Surely even children would smile if in the same thoroughfare two separate water-supply pipes were laid, and some houses took their supply from one of the systems while others preferred to be served by the second.

Consideration will show that it is the use of the tangible and suggestive pipe, or line, or wire, or rail which demonstrates to the mind that competition in the business which employs it is wasteful. We see clearly, without the need for even brief argument, that the rail, the pipe, the line,

the wire, ought to be used to the limit of its economic capacity, and that it is absurd to create a second or a third or a fourth, when the one would do. That is why everywhere, or almost everywhere, competition has been eliminated in the trades or enterprises referred to.

In every civilised country society has formed a co-operative framework without which life would be exceedingly inconvenient and uncomfortable. The common road is the simplest example of this framework, and in a civilised community it is maintained out of public funds, fed by the common contributions. We do not make individual and competitive tracks for ourselves; we agree that the function of providing and maintaining suitable roads should be discharged by public authorities, who perform their work with more or less of efficiency according to the degree of public spirit which obtains in any particular locality. We are apt to regard our roads as "free" because tolls have been abolished. As a matter of fact, we pay our road tolls when we pay our rates: and the bill we then discharge is in ultimate analysis as much a matter of "trade" as the act we perform when we buy a suit of clothes or a pound of butter.

The Co-Operative Framework of Society, that Includes Water-Supply, Drainage, and Lighting

The drainage and water supply have also come to be in very great part things of common use which are maintained as part of the social framework. When these things were left to individual and chance effort they were done so badly that great loss of life and much preventible suffering was caused The terrible plagues of ancient days were simply the result of the lack of an essential part of a co-operatively sustained framework of society. It is next to impossible for each family in a thickly populated community to dispose properly of sewage; and it is important to note that there is tacit agreement that the thing cannot be done by competitive enterprise. We do not argue about this; the argument is never raised. It is never suggested that the management and control of sewers should be left to private hands. That is a very significant fact, and it reminds us how commonplace important things become when the best way of working them has once been arrived at.

And thus it is again with lighting. Time was, of course, when the lighting of roads and streets was left to the hanging out of more or less efficient family lanterns, and when linkmen lighted to their destinations those who could afford to employ them. Nowadays, civilisation, from London to Peru, from St. Petersburg to Sydney, establishes and maintains public lighting of a very efficient character. The public lighting system is as much a matter of course as the public sewer, and it is so universally recognised that in these respects co-operation is the only sensible course that no argument to the contrary is ever heard of in any country.

Canal Ownership and the Postal System as Examples of Social Co-Operation

In some countries the canals have been placed on the footing of common roads, while in others tolls are charged. In others again, a private canal ownership is permitted, as in the United Kingdom. In every case, however, the necessity to eliminate competition is recognised, and we do not witness the absurdity of rival canals running side by side. As to railways, we saw in a former chapter that the general rule in civilisation is to bring these under public ownership. Even where private ownership prevails, however, competition is rare and impossible to maintain in the nature of the case. The same is true of tramways, telegraphs, and telephones.

As to the postal system, it is the universal rule to make it part of a social framework while charging users according to their degree of use. Nowhere in the world is there any competition in the postal business and it is freely recognised that it would be very undesirable for such a trade to be carried on upon a competitive basis. Nevertheless, we shall do well not to lose sight of the fact that it is quite possible for a postal business to be worked competitively.

What would Happen if the Post Were Worked By Competition

If the Post Offices of the United Kingdom or of Germany or France were abolished to-morrow, and the work left to the ordinary play of competition, there would at once spring up letter-carrying companies and firms in all parts of the country, each of them with a separate management and staff and accounts and so forth. In big centres of population, such as London or Manchester, Paris or Marseilles, Berlin or Hamburg, there would undoubtedly arise a number of local competitive letter carrying undertakings, each of which would necessarily have to keep accounts with the others. Under such a system, left to free competition, it is difficult to know what would happen to a letter. To pass from

England to Germany, it would have to go through the hands of a host of different agents, and the unnecessary work caused would be obviously very great. As a result, the cost of carrying a letter would be prohibitive to the poor, and a heavy tax upon even the well-to-do.

The postal business is a striking example of how to accept accomplished facts and cease to examine them, or even to think about them. We do not realise that it is only because the postal service has been made a public service in each country that we can with so much assurance post a paper envelope in an obscure rural postal box in the heart of England, and rely upon it that, in exchange for a copper or two, the tiny missive will be safely delivered within a short space of time in some obscure town in Canada, or Australia, or Bolivia, or the Transvaal. We have here a most striking illustration of what can be done by the exercise of the co-operative principle, but it is a lesson which escapes attention, because when an industrial miracle is performed every day, and every hour of the day, it ceases to be a miracle to us.

How the Milk Supply Might be Under Public Management with Advantage

Thus also it is, of course, in the domains which are treated in other sections of this work. The growth of a blade of grass, the budding of the trees in the spring, the nesting of a sparrow under the eaves – these are eternal miracles which have occupied the minds of the most profound thinkers produced by the human race. The unscientific man passes them by because of their familiarity, and because he has not been trained to read in Nature's infinite book of secrecy.

It is not only in those industries in which some visible material connection suggests the advisability of co-operation that co-operation is being secured. There is no real distinction between a business that is carried on by pipes and a business that is carried on without visible material tracks or connections. Water is a fluid, and milk is a fluid; and a moment's thought will show that it is no more necessary to have twenty suppliers of milk in a small town than it is necessary to have twenty suppliers of water. It is not, of course, possible to transmit the milk by means of a pipe, because its purity could not be preserved. If, however, the most economic result is to be obtained, it is clear that the milk supply of a town ought to be under a single control, in order that the cheapest and best results may be obtained, and all unnecessary expenditure of labour avoided, to say nothing of the great necessity of protecting people from the danger of impurity by contagion from a fluid which, because of its magnificent nourishing properties, is a terribly efficient conveyor of organic disease. If there are six, eight, or ten sets of milkcarts up and down a single road, it is precisely the same kind of economic arrangement as though there were six, eight, or ten water-pipes laid in the road. Obviously, the most economic arrangement would be for one cart to proceed to the road with a supply of milk sufficient for every family in it, and for the milkman to economise his time by passing from one door to the next consecutively.

An Illustration from the Unification of the Supply of Sewing-Cotton

By this means the milk trade would be carried on with the smallest number of men possible, and that freeing of labour which, as we saw in the last chapter, is the only way of increasing wealth would be promoted.

Or take the supply to the people of the United Kingdom of some common commodity of wide use, such as sewing-cotton. The making of sewing-cotton was at one time carried on in the United Kingdom by a considerable number of firms, large and small, with consequent waste of effort and unnecessary competition and advertising. Each of the firms, in its struggle with the other, had to employ separate staffs of travellers to push its goods: and there was, of course, the ordinary competition from the cutting of prices. Gradually the firms amalgamated, until at the present time the sewing-cotton business of the whole country is conducted almost in its entirety by what is, in effect, a single combination of producers working co-operatively with each other.

Manufacturers' Combinations Not Necessarily Detrimental to the Consumer

This has not come about through any application of economic theory; indeed, it has come about in spite of the predictions of some of the old economists that such a thing would be impossible. It has happened simply because it was borne in upon those engaged in the trade that they could save costs by combination and pooling of interests. In other words, the business men concerned realised that competition in their trade was wasteful. We do not pause here to consider the effect upon the consumer in detail, but we may say that it does not necessarily follow, from the existence of such a combination, that the consumer is worse off than he would be if the combination had not been formed.

Then, again, we have the remarkable instance of the combination of nearly all the wallpaper manufacturing firms of the country, in a single alliance made with the specific purpose of getting rid of competition. Another example is the combination of cement manufacturers. Cement is a manufactured raw material of great and growing importance, and the number of buyers is to be counted in tens of thousands. There are very few shops at which to buy, however, through the elimination of competition which has occurred, as in the other cases named, out of the development of ordinary business practice.

We do not pause to examine this matter in great detail, as we shall have occasion to consider it later in a further consideration of the economics of monopoly. It will be perceived that the co-operation of which we have been speaking has been effected from above. That is to say, it has been the work either of Governments, of local authorities, or of capitalists. It has been a co-operation in which governing powers, public or private, have effected the necessary changes or established the necessary conditions. There is another way in which co-operation has arisen, and that is from below. We refer to the great working-class co-operative and co-partnership movements.

The Successful Establishment of Co-Operative Shopkeeping at Rochdale

The essence of the co-operative movement is the elimination of the competitive industrial system by mutual association. The conception is that of mutual help—"Each for all, and all for each." The movement began in those terrible early days of the factory system, which did so much to degrade and destroy the manhood and womanhood of Britain. A number of high-minded men revolted against the horrors of industrial serfdom and child-slavery; and, not before human deterioration had proceeded far, legislative and other efforts were made to combat the evils. Amongst those men was counted a successful manufacturer named Robert Owen. In his own village and mills he showed that it was not only possible, but that it paid the manufacturer to care for his employees and to educate their children. After years of such practical experiment, he preached the gospel of co-operation to working people, counselling them to take into their own hands the control of industry. In 1824 the combination laws were repealed, and it became possible for working men to combine; 1834 saw the formation of the first successful co-operative society, the Rochdale Pioneers, an institution which still exists after seventy-eight years of useful work. The Rochdale Pioneers' Society was not the first co-operative body, for there had been a number of such efforts since about 1828, but it was the first to introduce the principle of restricting the rate of interest on the capital employed, and to *return to the purchaser of goods any surplus paid by him in price.* Such was the origin of the co-operative "dividend," as it is called, which is not a dividend in the ordinary sense, but merely represents what is saved upon ordinary shop prices through the co-operative methods of distribution.

Sixty Years' Growth of the Co-Operative Trading Movement

It is impossible in such a work as this to trace the entire history of the deeply interesting co-operative movement, but from 1834 onwards it has never looked back. The latest particulars published by the Board of Trade show that in 1909 there were 2233 productive and distributive co-operative societies of all kinds in the United Kingdom, with a membership of nearly 2,600,000. The value of the total trade of these societies, exclusive of banking, credit, insurance, and building society transactions, was in 1909 nearly £132,000,000, an increase of 75 per cent. in only ten years.

The main part of the business is done by the retail distribution societies on the plan of the original Rochdale Pioneers—*i.e.*, they return to the customer at periodic intervals the surplus remaining over between wholesale and retail prices, after paying all expenses.

The System by which Co-Operative Distribution and Production are Carried On

Membership in such retail societies simply means the holding of a one-pound share, but even one pound has not to be put down by a working man to join the society, because the usual rule is to admit on payment of a shilling entrance fee, and to allow the one-pound share to be accumulated by "dividends" on purchases. The retail co-operative societies are affiliated to wholesale co-operative societies, which buy wholesale—and in some instances manufacture—and act generally as wholesale agents and suppliers to the retail distributing societies. The Rochdale plan is also followed here. That is to say, the retail society buys from the wholesale society, and the wholesale society returns to it whatever surplus of profit remains on its purchases after paying a

moderate interest on capital. The retail societies, however, are not bound to buy from the wholesale co-operators, but they naturally do so as far as possible.

The growth of this working-class co-operative distributive movement, combined with an element of co-operative production, has undoubtedly been of great advantage to the working men concerned. The saving of retail profit means, of course, an addition to the wages of co-operators. The practice of co-operation, each member being admitted to the right to vote in the direction of affairs, exercises workmen in their own proper affairs, and gives them an insight into commerce. The control of managers, shop assistants, and, in the case of the productive societies, of industrial workers of both sexes exercises them as employers of labour. In this last respect there is the continual contest between the desire to secure as large a dividend or surplus on purchases as possible and the paying of good wages to the employees; and it is claimed by co-operators that they properly discharge their duties in this respect.

Co-Partnership as a Form of Co-Operation, but Differing from the Co-Operative Movement

It is not surprising that the great progress of the co-operative movement, which we have briefly outlined, has cut very deeply into retail trade. In some small provincial towns the co-operators are the largest traders, and the private tradesmen view with chagrin the loss of much valuable custom. As far as industrial production is concerned, the co-operative movement has not yet gone far. In 1909 co-operative production was worth £24,000,000, which, it will be perceived, is a very tiny fraction indeed of the production of the country as described in Chapter 7.

Another factor of considerable interest in which the principle of co-operation is involved is the co-partnership movement, which is based upon the conception of interesting all the workpeople of an industrial undertaking in its operations by making them actually partners in the capital undertaking and sharers in any dividends that may accrue. That is to say, it looks at the matter primarily from the point of view of the producer instead of from the point of view of the consumer, as is the case with ordinary co-operative societies. Such organisations may arise either from a combination of workmen entering into partnership with their own or with borrowed capital, or from a capitalist taking his workpeople into partnership. The co-partnership undertakings existing in the United Kingdom in 1912 include variations upon both these types. A co-partnership undertaking is to be distinguished from an ordinary co-operative society (1) because the actual workers not only draw wages but share directly in the success of the business through profit-sharing; (2) the actual workers have a right to become shareholders; and (3) the actual workers share in the management of the concern.

The Pros and Cons of the Co-Partnership Movement

Some sanguine people believe that they see in co-partnership the means to reconcile capital and labour throughout industrial life. On the other hand, it is pointed out by opponents that the creation of a multitude of small co-partnership concerns is not, in the long run, for the good either of the worker or of the country at large; it is urged that such small concerns would necessarily work in a small and inefficient way, and that they would be unwilling to combine with others of their kind to make proper economic units. Whatever the outcome of the movement, it is impossible to deny its extreme interest and importance. If its development proceeded far, and it was not found impossible to work on a large scale on such a basis, and great amalgamations of small co-partnerships took place, we should have large combinations of capital arising by another road from that followed hitherto.

The Various Interesting and Promising Forms Taken by the Spirit of Co-Operation

Summing up the many factors we have reviewed in this chapter, we cannot fail to be struck with the manifestation of the spirit of co-operation in so many different forms. We see co-operative effort originating (1) with the Governments of great States, (2) with local authorities possessing more or less of autonomy, (3) with capitalists, (4) and with workmen. We are entitled to hope from all these manifestations that the cause of civilisation is advancing rapidly, and that commerce is rising to a higher plane.

We can afford to be optimistic with regard to the eventual outcome of so many different experiments in the production and distribution of commodities, and to believe that the science of wealth production and distribution will continue to advance until it provides for every human being a sufficiency of material things won in honour and contentment.

A SCENE FROM THE DAYS WHEN CRIME WON FAVOUR BY DISGUISING ITSELF AS ROMANCE

SOCIETY AND CRIME

The Making of the Unsocial Ishmaelite, and the Problem of His Punishment

THE INCREDIBLE CRIMES OF THE LAW

No attempt at definition is more elusive than the attempt to define crime. It is wrong-doing against society; but who can fix a universal standard for its measurement? That standard is, technically, the criminal laws of each country, in that country. But the criminal laws of so-called civilised countries differ so widely that the very law which can be broken without crime in one country may be regarded, in another country, as itself a grievous crime. Every definition of crime seems to become narrowed down to time and place—it is true now, but was not true once; it is true here, but not elsewhere. Indeed, the broadest, because most humanitarian, view of crime would be the one most universally discarded, because only a few nations have yet responded widely to the moral atmosphere of human kindness.

Crime has been defined as a breach of conduct regarded as binding by the community. But what conduct, and how much of a breach? There are phases of wrong doing, reprobated socially and legally by the community, that do not amount to crime. It is impossible to define, generally yet precisely, where an offence against the law passes into a crime, when various ages, races, and lands are in disagreement respecting the criminality of even the most serious of all human misdeeds—the wanton taking of human life. Among people who, though nominally civilised, retain the duel as an approved institution, the taking of human life may be regarded as an honourable private obligation, whereas others would rate it as plain murder. It is the same in lands that are frankly uncivilised, where blood feuds involve a man's sense of honour, enlist his ambitions, and give piquancy and almost amusement to his life. They are our crimes, but his glories; and his community binds him by its traditions and present opinions to kill and spare not. It is clear that with such a disparity in views we are barred, geographically, from a universal definition of crime.

We also are barred from any consistent historical view of crime, for men's conceptions of it have been changing incessantly; and modern notions, as expressed in laws and punitive and corrective practices, are modern indeed—they only go back eighty years at most. The truth is that, so far as social organisation is concerned, we are living in a new world today a world far newer than we have any conception of until we begin to make inquiries into man's past and recent dealings with the whole range of social subjects, such as education, disease, crime, and poverty.

Consider some forms of crime as officially conceived in the past in nations reputed to be civilised and even Christianised. Just those activities which now are regarded as man's greatest glories have been his worst crimes. In particular, the crimes of thinking the best a man can, and believing what he must, have been treated as heinous, and punishable with the most brutal severity. Difference in opinion, when given a bad name, such as heresy, treason, blasphemy, rebellion, schism, or freethought, has been felt by governing cliques to be much more horrifying than imprisonment, tortures, and death; and it has been punished, legally, with ingenious cruelty that now looks fiendish. All that is at present called science has been specially repressed; and there is not a section in this publication which would not once, in Christian times, have shown ample cause for the hanging, drawing, and quartering of its conceivers, its writers, and its publishers. The heroes and martyrs were criminals of their day; and the Son of Man, Whose teachings are at last beginning to fructify, died upon a Cross.

Obviously we cannot glean a definition of crime from history, for it has always been flowing into fresh forms, under the shaping influence of law, custom, and opinion. Technically, it is a serious breach of important regulations which society adopts, formally or traditionally, for its own defence. The ideal on which those regulations are shaped is an evolutionary growth too swiftly changing to be caught by definition. It has only been glimpsed in the past, but we shall have a fuller view of it as we proceed; and for practical use here the conception of crime adopted must be that of our own country in these latest days.

The Criminal Section of Society that Has Never Been Trained to Accept Society's Conditions

The training of a people to the acceptance of the law, so that they not only do no damage to anyone, but cheerfully render duty on behalf of the community, is very closely similar to the training of the individual child. All young life starts with a love of freedom—the following of impulse—and has to be curbed and trained, by Nature's rough lessons, by traditional surroundings, by family and formal education. It has to be taught not to be mischievous, not to be selfish, not to be irregular, not to be untruthful through cunning or fear, but to have positive social virtues and to be proud of them. And so society shapes its members to an observance of its laws against damage. If they are never taught, but learn a contrary lesson, or if they cannot learn, or will not learn, or have not sufficient constancy of character to practise what they know that society rightly requires, they become criminals, either occasionally or constantly; and society, in its own defence, has to deal with them as unfriendly opponents. As every child has to be drawn from vagrant impulses, loosely selfish, and helped to a truer liberty sanctioned by the wisdom of its race, so with every member of society; and criminals are the comparative few who, because of birth, surrounding circumstances, or inherent defects in character, have never been able to fit themselves to society's deliberately adopted demands.

Born Criminals Few; Weaklings Moulded by Circumstances Many

In most cases the revolt against the laws of society that protect each member from damage in all its forms is individual, weak, casual, sporadic, furtive. But sometimes it is strong, conscious, organised, banded, and even may be supported by sectional growths of public sentiment. For example, though Ireland is a law-abiding land, save for a little exuberance of spirit, it threw, for many years, a shield of public opinion over agrarian crime. In certain Latin countries—districts of Italy, Greece, and Spain—and in the Western Highlands of Turkey, brigandage, from time to time, has existed by public connivance. The same popular concession was made when the highwayman was a romantic character, admired by people who were not likely to suffer from his thefts.

Then there is the conscious organisation of crime by international bands that plan great robberies, or elaborate frauds, in one capital city and carry them out in another. Crime cannot, therefore, be regarded as wholly individual. To a certain extent it is deliberately elaborated, and is sometimes supported by a limited amount of cliquish public opinion. In these cases it is, of course, a formal revolt against the defensive restrictions which human society has established by common agreement. But in the main, apart from deeply-schemed frauds and vengeful outbursts, those who are guilty of crime are weaklings of the race, in physique, morals, and understanding, who have never had a real grasp of the social responsibility which they disregard and outrage. At the most they understand their preying on society as a sort of contest or game—chiefly with the police—in which one or other scores, but their capacity or training has never allowed them to realise, with their full natures, the social meanness of their actions.

Lombroso's Mistake in Making Too Much of a Supposed Criminal Type

It is essential that this dual view of crime should be realised clearly, for on the lines of the distinction between the crime that springs from individual aberration and that which is born of social surroundings, past and present, two theories of criminality and its cure are based. One theory regards crime as the outcome of disease that is chiefly physiological or biological; the other sees it as essentially the outcome of social disease. The one denies that the criminal is responsible for his actions, because he was formed to be a criminal. The other is more concerned to bring responsibility home to human society as a whole for allowing those conditions to continue which make it easier and more natural for certain unfortunately born people to be criminal rather than to be honest and law-abiding.

While it is true that mention, by all who are interested in criminology, of writers like Nordau and Lombroso—followed in England by Havelock Ellis—should never

be made without gratitude, for they posed the criminal afresh before the view of society, and awakened for him pity as well as curiosity, it is also true that they gave an undue importance to the abnormal and occasional, and were inclined to treat as typical what was really accidental. Their examples were largely chosen, too, from the passionate Latin races, in whom temperament plays a prominent part, even when character is fairly well balanced. Lombroso went so far as to suggest that a distinct criminal type might perhaps be physiologically identified and separately treated by society.

The Need for Thinking More of the Made Criminal and Less of the Criminal Born

This too-definitive division was later seen to be distracting by the author himself, leading men's thoughts away from the more general type of criminal, and the social environments in which he has been grown—often through several generations.

Then, too, the students of sensational abnormality in the Latin races did not at first realise the value of what was being done in a remedial way in the United States and England to set finally on their feet the large class of criminal weaklings who fray off into crime from the edges of the industrial world. Lombroso's tributes to this work, and the Northern virility, energy, humanity, and philanthropy that organised it, became generous as the years went on, till he almost grew lyrical in his praise of preventive pioneers like Barnardo, and ameliorative and curative pioneers like Brockway, of Elmira. For our part, we shall leave the constitutionally abnormal criminal, after admitting his presence and the need for dealing with him largely on alienist lines, and shall restrict our inquiries to the drearily low average of human waste that keeps re-peopling our prisons, and that, to a large extent, is a social product, which may be largely eliminated by social care, training, and organisation.

The Type of Population from which Our Criminals Come

Who are the criminals with which industrial nations like England, France, and the United States have to deal? How came they to be what they are? What have been the circumstances that have allowed them, or caused them, to become enemies of society, disordering the social economy? Are they increasing or diminishing in number? And does the nature of their crimes vary for the better or the worse? First let us give a comprehensive glance over the class that accounts, to a large extent, for the dimensions of the police force, and altogether for the building of reformatories and prisons.

Here are some statistics, gathered from various official sources, that will enable us to fix clearly in our thoughts the average criminal type, and also partly to account for it. Inquiry into the antecedents of prisoners show that 70 per cent. of them come from families that have what may be called a prison history. Quite as large a proportion were truants from school, have a childish record of association with the borderland of crime, and are poorly educated. Though education stimulates some forms of crime, such as fraud and forgery, it is the ill-educated who commit the great bulk of crime, particularly of the rougher kinds. Thus in New York, where the illiteracy of the general population reaches 6 per cent., the absolute illiteracy of the criminal population reaches 31 per cent. Not more than 25 per cent. of the prisoners can earn a living in any skilled occupation, as we should expect from the fact that 77 per cent. have not been apprenticed to any trade.

Statistics that Show the Difficulty of Escape from Criminal Surroundings

Forty-five per cent. of the men who are in prison will come back, unless special efforts are made for their reclamation; and a larger percentage of the women. Of those who have been in prison five times, nearly 80 per cent. come back. The ages of the prisoners show that they are kept by the State during the years of their life when they are most capable of doing service in the world. Thus, only about 12 per cent. are over the age of 45; about 30 per cent are under 24; and 40 per cent. are between 24 and 34. All this shows that to an enormous extent our prison population is bred and reared for crime, amid surroundings and influences that allow but little chance of escape. As we know what the influences are which have made these men what they have become, we ought to be able to counteract such influences for the next generation, if we cannot nullify them in natures already corrupted.

For what offences have these people been shut up? Roughly, the wrong-doing may be arranged as 15 per cent. of acts of violence, 75 per cent. of offences against property, as in the cases of theft or fraud, and 10 per cent. of crimes of passion or lust. The prisoners are divided between the sexes in about the proportions of 85 men to

15 women. Those, indeed, are exactly the proportions of habitual offenders under sixteen years of age; over 21 the percentages are men 87 to women 13; and in reformatories men 88 to women 12, but in the United States the comparison is 78 men to 22 women. Women are usually charged with crimes of a less serious character, but when they become criminals they show a considerably larger share of absolute incorrigibles.

Much the larger proportion of crime is committed in the cities. London is a law-abiding city to a remarkable extent when compared with many crowded centres of population, but its offences against property are five times as numerous per thousand of the population as those of Cornwall. In all countries, density of population is one of the prime conditions for the inducement of criminal offences. In the towns the conditions of human degeneracy concentrate. The floating population, largely unknown, and unchecked by local opinion and restraints, is considerable. Accumulations of wealth and opportunities for stealing are close at hand, and living is dearer, competition keener, and sometimes unemployment more general. It is the towns, therefore, that produce the criminal class to a large extent, and furnish the conditions under which they may precariously subsist in a watchful warfare with society and the police.

Proofs of the Decrease of Crime in Recent Times

Is crime increasing or decreasing? That is a difficult question to answer, because of the amazingly different ideas of what constitutes serious crime held now and --as we shall presently show—in times past. On the face of the figures the present state of the country is one of sensational improvement. Take a comparison of the existing convict population with that of a past period. When the country had a total population of 15,000,000, its convicts, at home, on the seas, and in penal settlements, numbered 50,000. Now the general population is 45,000,000, and the convicts number between 3000 and 3500. In other words, we have, in proportion to population, one convict now where we once had fifty. But, of course, those were days when the offences which might turn a man into a convict were entirely different from the serious offences of the twentieth century. However, making comparisons with more recent times, the outlook is very hopeful. The number of young offenders convicted for offences against property has fallen by 46 per cent. in 17 years. Ten years ago 32 per cent. of offenders were recruits to the ranks of crime. Now that percentage is only 23. It may be said that this is chiefly due to new ways of treating first offenders; but that argument does not affect considerably the total number of indictable offences per 100,000 of the population proceeded with fifty years ago and today. Fifty years ago the number was 276 per hundred thousand. In 1909 it was 187. In that time there has been no great change in the character of offences, but a sound improvement in numbers.

The Past Story of Society's Treatment of the Criminal

We see, then, signs of progress, but still a weltering mass of settled and breeding criminality, recruited to some extent by physiological abnormalities and by the educated, who use their education to plan and execute what may be called the frauds of civilisation, yet, in the main, a low-type criminality, poor in physique, ill-reared, neglected, pitiable, insane to three times the extent of the rest of the community, with feeble understanding or sensibility, but still capable of improvement. How has this criminal class—with other offenders, so called -been treated in the past, and how should society deal with it in the future? It has been said that the treatment of criminal offenders has passed through the three stages of Revenge, Punishment, and Reform; or, in other words Repression, Segregation, and Reclamation. The advent of the spirit of justice in enforcing the laws for public safety and the protection of property is almost as recent as the effective regard for public health that was traced in our last article. Genuine civilisation dawned within the memory of the oldest inhabitant. Sanitary science only began to be effective about fifty years ago. Eighty years ago this country was in a state of savagery, so far as the punishment of crime was concerned.

The Ingenuity of Cruelty that Has Never Broken the Will of Man

We regard the Roman as inexplicably cruel in gladiatorial days, but as regards punishments he was, on the whole, more merciful than the Englishman of any period before the middle of the nineteenth century. Banishment and degradation from citizenship were among the most dreaded Roman punishments. It was the Teuton—the fierce Saxon, Dane, and Northman—who established the most cruel code of retaliatory and vindictive laws. And it took the world a thousand years to learn

that brutal and degrading suffering will not purge men's hearts of crime, but will leave them worse.

Human ingenuity has never been employed for a more barren purpose than that of trying to break the will of men by pain. Whether that will has been fortified by faith or by viciousness, harshness has rarely broken it down, except for the moment. Death by the cord, by the guillotine, by the axe, by strangulation, by poison, by flaying, by fire, by dismemberment, and by boiling in oil have all been tried as deterrents, and have not deterred. Torture on the wheel, on the rack, by crushing weights, by thumb-screws; and ridicule in the pillory, the stocks, the ducking-stool; the branding of cheeks, forehead, and breast; clipping off of ears, slitting of noses, and whippings innumerable have had a trial for centuries; and the misdeeds—real or supposed—that they were designed to correct have continued.

VINDICTIVE PUNISHMENT IN STUART TIMES—THE DREADFUL FATE OF THE GUNPOWDER PLOT CONSPIRATORS

The uselessness of these outrages on humanity might well have been all the while as apparent as their cruelty, and yet they were practised to within a nearness to our own times that makes us shudder at the proximity. People who have never read the history of their land ask sometimes whether there has been any real improvement. Here are a few facts that may help towards an answer to that question.

Boiling in oil was only used here in the reign of Henry VIII., but burning for crimes less heinous than murder continued to the year 1788. In that year, when Johnson was dead, and Burns and Cowper were writing, and Wesley preaching, a woman was burned in this country for coining. As for hangings, it is calculated by Sir James Stephen, in his "History of Criminal Law," that during the "good old times," when England had less than five million people, the average number going yearly to the scaffold was 800. This would give about 7200 hangings per year for our present population. That being the state of the case with serious punishments, we can understand how little would be thought of the fact that "every strong and sturdy rogue" who was locked up for vagrancy in the reign of Elizabeth was ordered to receive, in a preliminary way, as a matter of course, "twelve stripes upon his bare skin," while "every young rogue or loiterer" received six similar stripes, "with the whip provided for the purpose."

If the days of Elizabeth seem rather far off, what are our thoughts in face of the fact that as late as the year 1797 a man might be hanged for picking a pocket of more than a shilling; that there were then 222 offences besides murder for which hanging was a possible punishment; that in 1818 a vain attempt was made in Parliament to abolish hanging for stealing a sum of over four shillings from a shop; that as late as 1831 forty people were hanged in England for offences other than murder; and that in 1833 a child nine years old was condemned to be hanged for poking a hole with a stick through a papered-up window-pane, and stealing twopence-halfpenny-worth of paint? The child was not actually hanged, for hanging, except for murder, ceased in practice in 1832, though it was not abolished till 1861, and is still legal as a punishment for certain national crimes, such as treason. There was not much "moral compensation" for the public in these cruelties, and the continuation of the offences showed that safety was not secured.

While these terrible death-sentences were being pronounced all over the country, often to be followed by a vindictive mutilation of the corpse, or by hanging in chains on the gallows, there was a contemporaneous punishment in gaols that

was worse than death, and in many instances almost inevitably led to it. The most horrible phase of the wholesale distribution of death was that it brought to one level offences of every degree of enormity or triviality. A petty theft could be revenged by the same punishment as was allotted for the foulest murder.

The Promiscuous Imprisonments that Were Worse than Death

That was the secret of the ingenuity shown in producing the excrutiating forms of suffering which stamp certain Christian centuries with horror. Boiling in oil, for example, was a special form of death devised for poisoners. The fearful punishments in the gaols of the seventeenth and eighteenth centuries had the same atrocious feature —they levelled all distinctions in offence, and shattered alike the constitutions of the saintliest pioneer of a pure religion and the filthiest of rogues, the latter, of course, having much the better chance, because he was probably accustomed to filth and foul surroundings.

Originally the theory of imprisonment was that the person concerned was shut up for his safe custody, and not as a punishment. The village "lock-up" has existed in this sense, as many people now alive can remember, almost down to our own day. The drunken or boisterous man was locked up by the village constable to keep him safe from mischief to himself or others, as straying cattle were locked in the village pound. It was in this simple sense that John Bunyan was detained in Bedford Gaol —to keep him out of mischief, as local justice recognised mischief. But soon the prison passed into the House of Correction, and its purpose became distinctly punitive, though it was not till the year 1776 that the idea of "hard labour" was associated with the prison. Solitary confinement was not adopted as a policy until 1778.

The Gaol as the Disseminator of Diseases that Have Now Disappeared

Before that time the gaol was the common sink of criminal and unfortunate humanity, and the keeping of it was, to a large extent, farmed out for profit. The management was only made official, as we now know it, in 1774. During the fearful period of crowded gaols—crowded that there might be the more profit to the warden and those to whom he sub-let the work of fleecing the inmates—inspection of their condition was impossible in many cases, for the constant presence of typhus, or "gaol-fever," made a visit dangerous in the extreme. Indeed, the administration of justice in the ordinary courts was a perilous duty, for the smell of the prisons that had not been cleaned for months was brought into court, and judge, counsel, witnesses, and court attendants sometimes died the death that had been prepared in the foulness and stench of the gaol. On one occasion at Oxford, within forty hours of the opening of the prison for the assizes, the judge and three hundred others were dead.

As a means of relieving the crowding of the gaols with the victims of harsh and undiscriminating laws, the hulks—ship-prisons on the Essex coast of the Thames —were started, and transportation was resorted to, at first as a temporary expedient, though the system lasted eighty years. The conditions under which transportation was carried out have now been forgotten, but must be realised to appreciate what was the attitude of society towards the law-breaker in the days when no respect was paid to the personality of the delinquent. The aim was to get prisoners out of the country and off the hands of the authorities

The Days when Transportation was a Trade Speculation

To that end, contractors were allowed to compete for the conveyance of prisoners to the "plantations," and the profit of their labours there in slavery; and it was not impossible for the friends of a prisoner to waylay the convict ship that carried him overseas, and to buy him back from the contractor.

Such were the ideas and practices that approved themselves to society in its treatment of the men who broke its temporary laws, when British convicts were, in proportion to the population, fifty times as numerous as they are now. Much vengeful feeling wreaked its anger on all and sundry whenever the law was broken; the public supped full of horrors, in watching the outcome of crime and the expiation offered from time to time by its heroes; but for the prevention of crime, and the reclamation of the criminal class that formed such a large section of the community, nothing was done. When resentment and retaliation had exhausted their venom, public spirit asked for nothing further. The story of the awakening of the social conscience, and the reformation of methods of dealing with crime and criminals, is a story of these later days to be developed in our next chapter. It is a story in which the Anglo-Saxon race, in the British Isles and America, takes a very honourable part.

A STUDY OF UNWORTH

Is Mankind Degenerating Through the Propagation and Preservation of the Diseased and Unfit ?

THE NEED FOR REPRESSIVE EUGENICS

We now proceed from positive eugenics, the encouragement of worthy parenthood, to the converse project, to which we have given the name, approved and employed by Sir Francis Galton himself, of Negative Eugenics, and which we define as the discouragement of parenthood on the part of the unworthy. Compared with positive eugenics, this is simplicity itself, for we have far more knowledge, and can far more easily use the knowledge we have. All discussions and proposals of eugenics, therefore, tend constantly to take the line of least resistance, and to concern themselves with this subject alone. Sir Francis Galton, who had not included this under eugenics as he defined it, himself came to admit that it was the most urgent part of the campaign. But it is not the most important; and that is why we have here spent so much space upon the positive part of our proposals, for we shall not raise the race or directly increase the amount of worth in the human species merely by purging it of diseased elements, however necessary and desirable that process may be. Eugenists must beware of supposing that they have done any more than a preliminary piece of work, prior to a fair start, when they have achieved, for instance, sound legislation regarding the feeble-minded.

Two other points of primary importance require to be made in introducing this department of our subject. One of them has been ignored through sheer cowardice, and the other has only lately been made plain by the American researches. Any student of this subject may look in vain through the eugenic literature of the last septennium for any recognition of the points in question. One is that marriage does not coincide with parenthood, and that, when we wish to interfere with parenthood alone, we are not therefore entitled to interfere with marriage. That is why we have here defined negative eugenics as "the discouragement of unworthy parenthood," and not as "the discouragement of marriage on the part of unworthy persons." Very often the two projects might coincide, but there is a fundamental distinction between them; and the tendency to confound them must often mean that eugenists, with inexcusable impertinence, seek to interfere with marriages that might be happy, beautiful, and valuable, on the part of responsible persons who do not mean to have children. Success along this false line would further mean grave injury to the institution of marriage, and very possibly a rise in the birth-rate of illegitimate and defective children.

The second point has also been referred to. When the eugenic campaign was started, when the writer included "negative eugenics" within it, and even as lately as two years ago, we assumed that, on general Galtonian and "biometric" principles of heredity, there was a certain average resemblance between parents and offspring, by which we must be guided. A feeble-minded parent would probably have similar children, and a whole-minded parent likewise. Sir Francis Galton entitled his Herbert Spencer Lecture "Probability the Foundation of Eugenics." But the rise of genetics, and especially the study of human genetics in America, has changed all that. We learn that the feeble-minded person is certain to have nothing but feeble-minded offspring, provided that the other parent be feeble-minded—that is to say, from the feeble-minded individual nothing but feeble-mindedness proceeds—"the empty germ-plasm yields only emptiness." But we learn, further, that all whole-minded individuals cannot simply be regarded as equally likely to have normal children It

all depends. If there be no feeble-mindedness in the stock, then the children are *certain* to be normal, except for the action of those special factors from without which may possibly *originate* defect.

On the other hand, many normal people carry defect which may appear in their offspring. It thus becomes an urgent necessity to distinguish the pure and the impure dominants in a population, where we are dealing with a disease which is a recessive. The people who do not display it, owing to the personal possession of the dominant character, may be either pure or impure dominants. The latter will transmit the defect in a proportion of their germ-cells, and the defect will appear in each child to whom it is transmitted if the same defect has gone into the composition of that child from the other parent. We begin to understand the prejudice against the marriage of cousins. If they be cousins from a defect-bearing stock—neuropathic, epileptic, or feeble-minded—then, though personally normal, they will be liable to have some defective children when the recessive character in a germ-cell from one parent meets the recessive character in a germ-cell from the other.

The Difficulty and Complexity Introduced by Dormant Unfitness

The policy of Negative Eugenics, in the real world, under the conditions of society, of public opinion, of law, and of human desire, thus becomes incalculably complicated, so far as the complete extirpation of an undesirable recessive character is concerned. With dominant characters that are undesirable we can deal more readily, for every individual who can transmit a dominant character, having it in his or her germ-cells, also *displays* it—that is why we call it dominant. The problem of the worthy individual who may carry unworth, therefore, does not arise, where the unworth is a Mendelian dominant. The so-called "unfit" whose "unfitness" depends upon a dominant character can be dealt with directly. They will probably need special care, and that care will incidentally deprive them of parenthood. But, unfortunately, the most important characters with which we have to deal—mental defect or feeble-mindedness, epilepsy, and the neuropathic or insane taint—are all recessives, probably of a simple nature; and this means that they may be borne and transmitted by "impure dominants" who are personally normal. How are we to deal with such persons? Here is the new problem we are called upon to face; and its solution will be no easy one.

Our discussion of negative eugenics would theoretically require to comprise all known forms of transmissible unworth. Here we shall make no such attempt, for two sufficient reasons. The first is that the principles apply to all cases. The second is that the three allied forms of unworth to which we have just referred—mental defect, epilepsy, and the insane tendency—are by so much the most important and urgent of all, and our neglect of them is so scandalous, that our clear duty is to concentrate upon them until the community can be persuaded to deal with them properly.

The Need for Dealing First with Urgent Types of Transmitted Disease

It would be possible to discuss various rare deformities and defects of the eye, such as premature or pre-senile cataract, many defects of the skin, many defects of the nervous system, such as "Gowers' disease," and hereditary ataxia (Friedreich's ataxia), and at least one defect of the blood, namely, hæmophilia, or the "bleeding disease," and to show that each of these must be dealt with under the principles of negative eugenics. But all of these cases put together are relatively trivial in number, and in importance of any kind, compared with the three forms of nervous defect which we have named, and to which deaf-mutism may be added as a related and not unimportant fourth, only that its genetics is still imperfectly understood. Therefore, on the principle of "first things first," we shall here confine ourselves to these leading nervous forms of "degeneracy."

The Worst Cases of "Unworth" Easily Recognisable by All

By thus making our discussion definite instead of vague we save time that would otherwise be spent with those who ask what constitutes worth and unworth. Anyone whose mind is not of vegetable stolidity can make pretty play with such inquiries, ending with the obvious conclusion that we shall all be locking each other up soon. This argument has been so often repeated and answered that much further use of it will indeed have to rank as a qualification for segregation shortly; it betrays the fact that the user is uneducable, a serious matter in a human being. Those who are willing to learn and capable of learning do not need telling that an idiot or a victim of epileptic insanity is an example of the kind of thing which we do not desire to multiply. If society and philanthropy and medicine all

devote themselves to the cure of a certain disorder, we may surely agree that it comes under the rank of unworth as we understand the term. The fact is that this argument is never employed save by those who have no first-hand knowledge of these unfortunate people, or who, in other words, have never done anything for them. No one who has ever devoted an hour to the protection of a feeble-minded child, or who has been responsible for the tongue of an epileptic—lest the teeth involuntarily harm it during a fit or who has spent a day endeavouring to cheer the life of a deaf-mute, ever asks these useless and dilatory questions.

Foolish Objections Made by People who Have Given No Thought to the Question

The case is similar to that of the children excluded from public-houses under the Children Act. All of a sudden the champions of childhood were multiplied a thousandfold. From all manner of surprising quarters there appeared indignant people furious that children should be exposed to cold outside public-houses. Their letters filled the papers and their questions occupied the time of political meetings. Only one thing was certain about all of these people—that not one of them had ever done anything for the care of infancy or childhood in his life. Those who had knew better. So here. The protesting parties, who argue that we do not know who are the unworthy, in the eugenic sense, that we are all feeble-minded in one way or another, and so forth, at once label themselves as having never done anything for the poor creatures under discussion.

Those who have know better. They may be doctors, nurses, poor-law guardians, old ladies, clergymen, parents; it does not matter in the least what their age, sex, education, social status, or professional interest. If they have done anything for these people, they know what category of mankind they belong to—the category of those for whom it had been better had they never been born.

Doubtful Borderland Cases Must Not be Interfered With

No one but an idiot argues whether or not it is good that idiots should exist. Those who do argue on this question simply have had no opportunity of observing, still less of being responsible for, the people whose continued neglect they champion. Let us have done with such trifling.

There are "borderland cases," which raise a new problem. Everyone who has ever seen a case agrees that the typical feeble-minded girl should not become a mother; but what about the girl who is not exactly "right," but who is not definitely feeble-minded—who seems "all there" at one time and "wanting" at another? Few questions have oftener been directed to the writer at public lectures during the past septennium than this. His reply has always been and still is that, when in doubt, we must beware of interference, for we shall do far less harm to eugenics thus, in the long run, than by interference which turns out to have been unwarrantable.

So much having been asserted, let us make two further observations. The first is that the number of these doubtful cases is far smaller than most people suppose, and will steadily diminish as our attention to the *nurture* of childhood increases, for these "borderland cases" are mostly those whose condition is due to defective conditions of development. Those in whom the defect is natural or genetic, and therefore transmissible, offer only too little room for doubt, in practically every instance. The second observation is that our doubt regarding some does not discharge us from doing our duty to the others, especially if the doubtful be few and the doubtless many.

The Much-Discussed Question—Are the Defectives Increasing?

When we come to the practical solution of these problems we shall see how much simpler their solution is, in this respect, than is supposed by those who have done nothing towards helping the defective part of our population.

A constantly recurring question occupies far too much of the time of controversialists. Workers have no time for it. Are the defective increasing? is the query which seems to fascinate most people, and everything is made to hinge upon it. There seem to be plenty of people who would be content merely to contemplate the defectives so long as there were no more of them than there used to be, or even so long as they only increased in the same ratio as the normal population.

In the "Pall Mall Gazette" there has lately been carried on a most acute, not to say aggravated, correspondence between Dr. Forbes Winslow and several other gentlemen on this old question, "Are we degenerating?" Of course, it is a interesting question, well worthy of discussion, but our duty to the existing defectives, whether they be two or two hundred thousand, and to the future, does not depend upon the answer to it.

Perhaps that is as well, for the question is no easy one. Its main features may here be defined, but only on condition that the reader will not allow himself to be led away into the immoral and impossible position that if the defectives are increasing we must do something, and that if they are not they do not matter. The merits of this question depend neither upon the number of those concerned nor upon what the number was at any previous date. If there were just one feeble-minded child in the Shetland Isles or Somerset, and there never had been such a child in our land before, our duty to it would be just what it now is to all the feeble-minded children there and elsewhere.

A Quarter of a Million Insane or Feeble-Minded in Great Britain

No final *data* exist for the estimation of the facts; and the arguments commonly adduced are none of them more than indicative or suggestive. The report of the Royal Commission on the Care and Control of the Feeble-Minded -the terms of reference of which were extended, subsequently to its appointment, so as to include a study of the insane also—furnishes some approximate figures regarding the *data* under its review. Those figures are and could only be approximate; and as for the tendency of movement we can only guess. Thus we can say that approximately a quarter of a million of the population of the British Isles is either mentally defective or mentally alienated—either idiotic, imbecile, feeble-minded, or else insane. These two categories divide the total about equally between them. The ratio of this figure to the total population can be readily estimated, and so far all seems simple. But we must remember that we are only reckoning here those of whom there is some kind of official cognisance; and that reckonings at any time can only comprise those who are in some way or other registered or certified.

The Steady Increase of the Unfit and Their High Birth-Rate

Now, two alarming facts can be added, and between them they seem to be conclusive. One is that the known number steadily increases, and the other is that the birth-rate among this section of the community is higher than among the normal population. The verdict seems irresistible, therefore, that the defectives are gaining upon us, and that, in the loose fashion of a loosely framed and useless question, "we *are* degenerating." This is very widely asserted, not least by one or two authorities of rank, and the essential evidence in its favour is that which we have cited. The known numbers increase, and the birth-rate of the defectives is higher, so that "they multiply more rapidly." Attentive and critical readers of POPULAR SCIENCE will look twice at the words "so that," but people in general, including many experts, have no question as to the unchallengeable validity of the inference. Yet it is a worthless inference, as we will show.

First, then, as to the absolute and officially verified increase in numbers. How far are the official numbers of today comparable with those of the past? That is a rather disconcerting question which we must try to answer. If the official numbers comprise, and did comprise, the whole, we know where we are. If they comprise, and did comprise, any constant proportion of the whole, we similarly know more or less where we are. But if, for instance, the official numbers have continually been comprising a larger proportion of the whole, so that perhaps 90 per cent. of cases are now known, as against 45 per cent. half a century ago, what exactly do the figures prove – especially if no one can possibly say what the certified proportion really was at any past date?

Some Apparent Increase Due to the Increase of the Insane Publicly Treated

Complicate the problem a little further by asking what the ratio of the number (in any case unknown) was to the whole population at each decennial period, say, from 1851 to 1911, and we begin to see how many questions have to be answered before we can confidently say whether or not "we are degenerating." But if such indispensable preliminary inquiries were a *sine quâ non*, the newspapers would have fewer correspondents, perhaps.

Only two certain facts may be asserted as beyond argument. One is that, as we have seen, the known number of defectives increases; and the other is that the proportion of the known defectives to the whole number of defectives also increases. As has been repeatedly pointed out by Dr. F. W. Mott, by Dr. Robert Jones, and many other students of mental disease, popular confidence in institutions for the insane has been steadily rising, and with reason, for many decades past.

The public at large knows the difference, but only those who have had special opportunities of reading and of personal experience can realise how great it is. Hence, a far larger proportion of the insane now enter such places, and the comparative

figures, as they stand, prove nothing. Further evidence of various kinds assures us, however, that the total number of the insane and defective must be greater than in the past. Whether it is greater in proportion to the population is another question. We have no *data* on which to form a conclusion. Very possibly the ratio is increasing, but perhaps it is not.

At this point the second established numerical fact of the defective is quoted. "How can you say that you do not know whether they are increasing when you yourself admit and quote their higher birth-rate?" Many observers have apparently shown that the birth-rate among the insane is high. Some have shown that the families of the feeble-minded average 7·1 in number, as against the four of the normal family. It is not asked how many of the feeble-minded have families at all, as compared with the normal; and still less is the crucial and all-important question asked, "How many of those born reach reproductive age?"

The High Death-Rate of the Unfit, and the Large Infantile Mortality

No doubt it is true that the feeble-minded parent has more children than the normal parent. It may or may not be the case that the birth-rate among the defective part of the population is higher than among the remainder. But none of those who quote the birth-rate, or what is supposed to be known about it, have followed their investigations to the point at which they become useful. The question is not the absolute birth-rate, but the effective birth-rate. In Germany the mortality of the whole population from birth to the end of the fifth year is as high as the mortality in this country up to the end of the twenty-fifth year, as Dr. Havelock Ellis has lately pointed out. The case of the fulmar petrel, cited by Darwin, is here relevant again; its birth-rate is extremely low, but it is the most numerous bird in the world. Now, directly we realise how inadequate a figure is the birth-rate alone, and begin to look at the death-rate among the normal and the defective sections of the population respectively, we discover that the death-rate is far higher among the latter, as might have been predicted for many obvious reasons—their excess of poverty, and of illegitimacy, their inability to protect themselves, the incapacity of the parents, and so forth. Dr. Welsh Branthwaite, his Majesty's Inspector of Inebriates, in his annual official reports, which are documents of the highest value to students of eugenics, has shown that the death-rate among the children of the feeble-minded inebriate women in our reformatories is huge; perhaps not more than half of them ever reach the reproductive age. The circumstances which explain this enormous death-rate also explain the difficulty of getting accurate figures—the mothers often cannot remember how many children they have had, and cannot trace those they can remember. But even under these conditions it can be shown that the death-rate is monstrous.

Apparent Increase in Insanity Due in Part to a Rise in the Standard of Sanity

Yet which of the numerous alarmists who assert our national degeneracy on the two grounds here cited—the increase in the number of the certified defective, and their large families—has given any attention to the qualifying circumstances which are here noted, and with which every trained student of vital statistics is familiar? It is certain that the number of defectives increases; it is also certain that the population as a whole increases. Whether or not the defectives are increasing out of proportion to the remainder no one can positively assert on the grounds of any existing *data*.

It is not merely as if the difficulties already noted were all. There are several more, two of which may be quoted, by way of clinching the argument against those who profess to have exact knowledge, and who quote statistics, on this subject. One is that, as Dr. Robert Jones and others have pointed out, the *standard of sanity* tends to rise. People who would have been put down as merely peculiar, or eccentric, or wayward, only a few decades ago, are now recognised as insane. In many such cases experience shows that the individual is safer and happier under proper supervision, and so he goes down in the records, and helps the arguments of those who say that we are degenerating. In reality his case proves nothing.

Further Comparative Increase in Number Because of the Healthiness of Asylums

Secondly, the death-rate in asylums has fallen quite astonishingly. They used to be hotbeds of consumption, especially in days when the nature of the disease was unknown and ventilation was at a discount. Other maladies associated with overcrowding and defective sanitation were also rife. But nowadays an average asylum is a far safer place to live in than the average home. The inmates live instead of dying.

Yet one more preliminary question arises, which must be asked and answered of each

individual case in each of the four categories to whom we have referred—the insane, the feeble-minded, the epileptic, and the deaf-mute. For the purposes of science and of eugenics, each of these groups of persons must be divided into two categories, which we may style the natural and nurtural, "congenital" and "acquired," genetic and somatic, inherited and not-inherited, transmissible and non-transmissible.

So far as the treatment and care of the individual is concerned, therefore, our course is clear. The deaf-mute child needs to be taught to talk on its fingers or by the oral method, no matter what made it deaf-mute. The epileptic requires to be protected against the harm he may do himself in a fit, no matter whether the fits are due to a blow, to some parasite under the skull, or to a native and genetic peculiarity in the structure or function of the nervous system. No argument as to causes is to be allowed place for a moment if our care of the individual as an individual is to depend upon it. But for eugenics, to say nothing of arguments about national degeneracy, such argument is all-important.

The Insufficient Study of Deaf-Mutism on Mendelian Lines

Unfortunately, the genetics of deaf-mutism has not yet been worked out, though we may hope for help shortly from that unweary student and champion of the deaf child, Mr. Macleod Yearsley. Meanwhile, it is clear that Mendelian principles are somehow involved, including that "skipping a generation" which used to be looked upon as a kind of freak on the part of heredity, but which Mendelism has taught us to understand as a normal part of the genetic process. The obvious conclusion is that, by study of the individual history, and of at least three generations of the racial history, we must distinguish between the genetic and somatic cases of deaf-mutism, permitting or welcoming marriage and parenthood on the part of the latter, which are non-transmissible, and doing our utmost to discourage parenthood on the part of the former, which are certainly transmissible.

In the remaining categories the same distinction exists, with the same practical consequences, but, unfortunately, it is much more difficult to recognise, at any rate in many individual cases. In the great majority there is no doubt, for, in fact, these are the palpably genetic cases. But there remain an important minority where we cannot be sure, at any rate until some time has elapsed. The reason for the special difficulty in these categories as compared with, for instance, deaf-mutism is evident. It is that the mind is so sensitive and plastic, and that we have to deal with immaterial factors like worry, sorrow, and so forth, with the result that the exact relation of the genetic factors and of the factors of nurture, infection, companionship, responsibility, mental strain, and so on is often difficult to estimate. A very trifling external cause will induce insanity in the predisposed, but even in the normal, not predisposed, some appalling combinations of causes may induce it.

The Necessity for a Widespread Study of Family Histories

If we are to meet this difficulty in any adequate degree, it is the study of pedigrees that will help us. We must call in aid the facts of the racial history of the individual, and if we set properly to work we shall find evidence, for or against—usually for—which will decide the question, genetic or not genetic. Hitherto this necessity has been very imperfectly met. "Family histories" are no doubt recorded, but they are not extensive enough. Nothing suspicious is found in the parents or grandparents; no first-hand inquiry, after the American pattern, into the real facts of those persons is made, and the report is that there is nothing in the patient's heredity. But in the neighbouring asylum the facts are studied more carefully; and so, while one superintendent says that 30 per cent of insanity is due to heredity, another puts the figure at 75 per cent. Public and professional opinion must demand something better than this.

The Terrible Results of Freedom for the Spasmodically Insane

The most serious consequence of our present carelessness can only too easily be stated. The nature of the greater number of cases of insanity being misconceived, asylums compete as to which shall have the largest percentage of "cures." The "cured" patient must of course be discharged, to rejoin the wife or husband outside. Then, the future population of the insane having been recruited, the "cured" patient unfortunately has a "relapse," and returns to the asylum, and so on, *ad libitum*. This is a glaring evil which requires immediate attention. How rightly to deal with the problem offered by the insane population of the country is the next practical question to which we must address ourselves.

STARS IN THEIR COURSES

The Naming of the Constellations and Making of the Map of the Sky

WHY STARS TWINKLE AND PLANETS DO NOT

We now enter upon a vaster study. The sun and his system of planets, which have seemed to be proportioned upon such a prodigious scale, must dwindle in our imagination until they become a mere point of light in the black heavens, one star among uncounted millions. Gazing at the starry skies upon a moonless night, and letting our vision wander through their brilliant labyrinth, let us realise that somewhere there, in that innumerable company, floats a star which is our sun. Our earth and solar system are henceforward only our standpoint and observatory.

Viewed from this drifting point in infinite space, all the host of heaven are seen projected upon the interior of a hollow sphere; and so projected, they fall into various patterns or figures, of which the more conspicuous have been known from ancient times as constellations. These figures are quite arbitrary; for the most part, though not always, revealing no astronomical relationship between the stars which enter into each of them. They do not necessarily show comparative nearness of the stars which form them; for the stars are seen in perspective, so that of two which appear quite close together upon the hollow sphere, one may be immeasurably away behind the other.

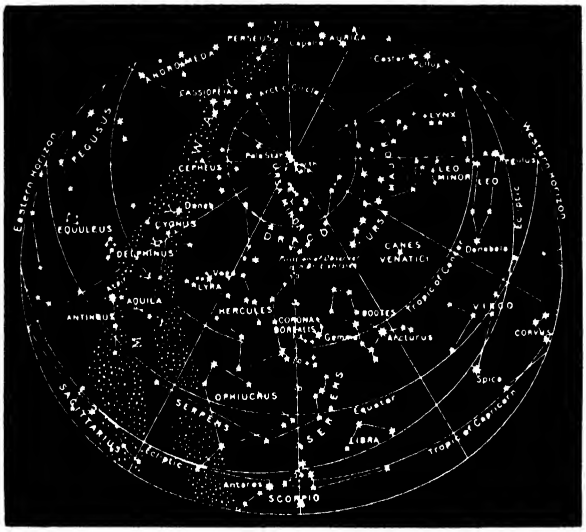
Again, the stars might have been grouped in quite other figures than those that have been handed down to us by tradition. Indeed, the present arrangement is, in many cases, not the most convenient which might have been made. Sir John Herschel said of it that "the constellations seem to have been almost purposely named and delineated to cause as much confusion and inconvenience as possible. Innumerable snakes twine through long and contorted areas of the heavens where no memory can follow them; bears, lions, and fishes, large and small, northern and southern, confuse all nomenclature."

This, however, is the language of exaggeration. Only eighty-five constellations are recognised by modern astronomy, and divide among them the whole area of the celestial sphere; and the confusion which is caused by their irregularity is as nothing to that which would arise if astronomers were free to invent new combinations of stars. Moreover, the very antiquity of the constellations, of which many were fixed by early Chaldæan star-gazers, deserves our respect. The names of Orion, the Pleiades, and others, are as old as literature.

A Greek astronomer, Eudoxus of Cnidus, wrote a treatise upon the stars, dividing the heavens into the constellations as these were known in the fourth century before our era. He enumerated forty-five groups of stars, but the number was increased to forty-eight by Ptolemy of Alexandria, in the second century A.D. From this time the system of constellations remained fixed until it was revised by Johann Bayer, a German astronomer born in 1572, who published in 1603 a chart of the heavens which, for that age, was wonderfully complete. Besides adding twelve new constellations to those already accepted, Bayer devised the method by which the stars in each constellation are individually distinguished by letters of the Greek alphabet, the most brilliant being described as α, the next in brightness as β, and so on. Other constellations were added by Tycho Brahé and succeeding astronomers until the middle of the eighteenth century, when the process was fortunately brought to an end. But the precise boundary lines of the constellations remained undetermined until this work was undertaken in 1840 by a committee of the British Association. The whole hollow sphere of the sky was by them

definitely divided by unmistakable boundaries into the irregular areas of the constellations.

These constellations, or asterisms as they are also called, are as follows. Andromeda, Antlia (air-pump), Apus (bird of paradise), Aquarius (water-carrier), Aquila (eagle), Ara (plough), Argo (the legendary ship, subdivided into Carina "keel," Puppis "poop," Vela "sails," and Malus "mast"), Aries (ram), Auriga (charioteer), Boötes (or Arctophylax, "the bear-keeper"), Camelopardalis (giraffe), Cancer (crab), Canes Venatici (hunting dogs), Canis Major (greater dog), Canis minor (lesser dog), Capricornus (goat), Cassiopeia, Centaurus (the centaur), Cepheus, Cetus (whale), Chamæleon, Circinus (compasses), Cœlum (heaven), Columba (dove), Coma Berenices (hair of Berenice), Corona Australis (southern crown), Corona Borealis (northern crown), Corvus (crow), Crater, Crux (southern cross), Cygnus (swan), Delphinus (dolphin), Dorado (goldfish), Draco (dragon), Equuleus (foal), Eridanus (an ancient river), Fornax (kiln), Gemini (twins), Grus (crane), Hercules, Horologium (clock), Hydra, Hydrus (water serpent), Indus (Indian), Lacerta (lizard), Leo (lion), Leo Minor, Lepus (hare), Libra (scales), Lupus (wolf), Lynx, Lyra (lyre), Mensa (table, after Table Mountain), Microscopium (microscope), Monoceros (unicorn), Musca (fly), Norma (rule or square), Octans, Ophiuchus, Orion, Pavo (peacock), Pegasus, Perseus, Phœnix, Pictor (painter), Pisces (fishes), Piscis Australis (southern fish), Piscis Volans (flying fish), Reticulum (net), Sagitta (arrow), Sagittarius (archer), Scorpio (scorpion), Sculptor, Scutum Sobieski (shield of Sobieski), Serpens (serpent), Sextans (sextant), Taurus (bull), Telescopium (telescope), Toucan, Triangulum (triangle), Triangulum Australe (southern triangle), Ursa Major (greater bear—also called the Plough, or Charles's Wain, or in America the Dipper), Ursa Minor (lesser bear), Virgo (virgin), Vulpecula (little fox).



THE CONSTELLATIONS VISIBLE IN SPRING

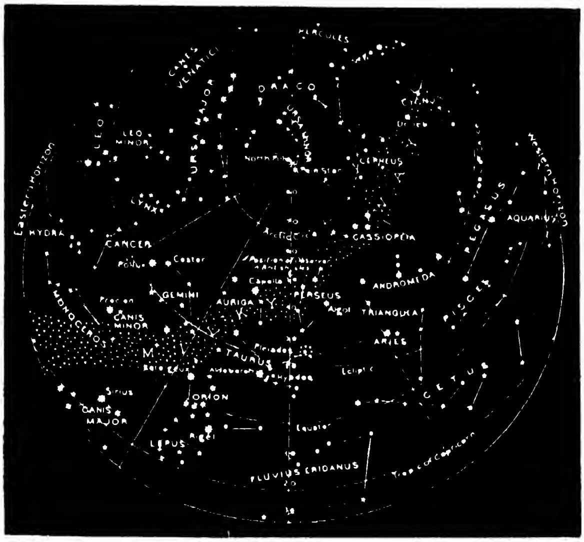
It is a queer list of names, mostly "a menagerie stocked from the banks of the Euphrates," with a few names of mythical heroes, and a few objects of human handiwork. Strangely enough, there is not one constellation named from the vegetable kingdom, not an oak nor lily nor rose, as if these ancient Chaldæans had eyes only for beasts. Giordano Bruno suggested naming the constellations all over again, with the names of the virtues; and Julius Schiller, not long afterwards, would have changed them into monuments of the saints. They are better named as they are. No modern could have named them so exuberantly; our eyes see no dragons nor lions nor scorpions in the sky; we see only geometrical figures.

THE CONSTELLATIONS VISIBLE IN SUMMER

Not only constellations, but individual stars also, have names; some grand, as Sirius and Arcturus; some uncouth, yet

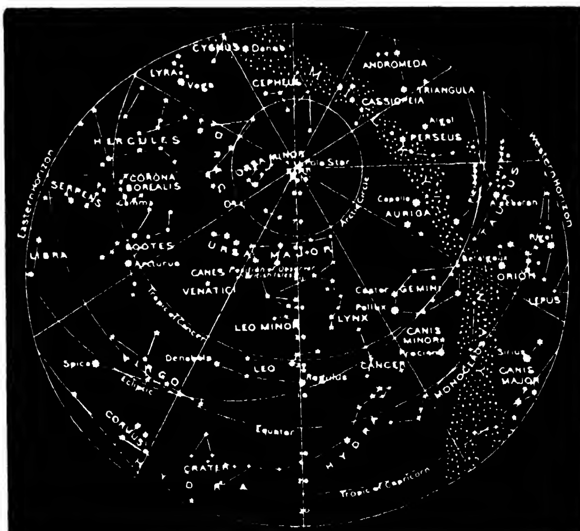
magnificent too, as Betelgeux, Aldebaran, and Fomalhaut. These last are Arabic, memories of the time when the Arabs were the first mathematicians and astronomers of the world. But such kingly names as these are not for modern science; the swiftest star in all the heavens is known as "1830 Groombridge."

The number of fixed stars which are visible under the most favourable conditions, without telescopic aid, in the entire sky of the north and south hemispheres, is estimated at less than seven thousand. But the observer in any one position on the earth's surface cannot see more than about two thousand stars, even on a perfectly clear and moonless night, because many which would be visible overhead are hidden by the deep atmosphere towards the horizon. The atmosphere cuts off the light of a vast number of stars; if it were removed we should see eight or ten times as many. With an ordinary field-glass a vastly greater number of stars can be seen than are visible to the naked eye. The smaller stars are far more numerous than the larger; so that in general it may be said that the total light given by stars of the second magnitude is more than the total light given by the stars of the first magnitude, and the light from stars of the third class is more than the light from those of the second, and so on throughout the first eight or ten magnitudes. The stars which are invisible to our eyes shed more than three times as much light upon a starlit scene as those which can be separately perceived, and the total amount of starlight may be taken as about one twentieth or thirtieth of the light of the full moon. It is impossible to give more than a very rough estimate of the total number of stars which are visible by means of the most powerful telescopes; sixty millions has been accepted as a probable figure by several good authorities. It must be remembered that the number of stars is definitely limited, because otherwise the nocturnal heavens would blaze with light like the face of the sun.



THE CONSTELLATIONS VISIBLE IN AUTUMN

The magnitude of a star is a term denoting its degree of brilliancy as seen from the earth, but it is not meant to imply that fixed stars have any visible dimensions at all. The apparent brilliancy of a star depends on three factors its actual size, its actual brilliancy, and its distance from the observer. In the vast majority of cases not one of these factors is known. A star which is actually large and brilliant in comparison with others may yet appear less brilliant than they, if it is much further away from us than they are.



THE CONSTELLATIONS VISIBLE IN WINTER

The stars which are visible to the unaided eye were divided by ancient Greek astronomers into six classes; and their method of classification, extended to include the less brilliant stars which are visible only by means of the telescope, is in universal use today. The brightest stars are those of the first magnitude, of which there are ten

in the northern and ten in the southern hemisphere of the heavens; those which are just visible without the aid of instruments are of the sixth magnitude; and the stars which are intermediate between these two classes are graded as being of the second, third, fourth, and fifth magnitudes. The stars of the first and of every succeeding class differ of course greatly in brightness among themselves, because this classification is quite arbitrary, so that a star which is just within the first class may be but little brighter than a second magnitude star which is among the most brilliant of its class. Yet an average brightness for each class may be estimated; and when this is done, it is found that an average first magnitude star is about one hundred times as bright as an average star of the sixth magnitude. This implies that each magnitude is as nearly as possible two and a half times as bright as the next succeeding magnitude, and the same proportion holds all through the scale. A star of the first magnitude is one hundred million times as bright as a star of the twenty-first magnitude.

The Minute Classification of Stars by Their Brightness

In view of the fact that the stars of any one class differ among themselves to such an extent that one of them may be more than twice as bright as another, the classification is now made more exact by admitting decimal figures. Thus, besides the magnitude 2, we may specify stars as being of the magnitudes 2·1, 2·2, etc., in a descending scale of brightness, down to the magnitude 3. And further, in view of the fact that the twenty stars included in the first class differ among themselves to a degree much exceeding the limits of a magnitude in other parts of the scale, it has been found necessary to establish a magnitude zero to indicate two and a half times the brightness of the normal first magnitude; and above zero, again, the magnitudes of minus one, and even minus two, have been used to express the brightness of Sirius and of the planet Jupiter respectively.

Among the stars of the first magnitude are Achernar (in the constellation Eridanus), Aldebaran (Taurus), Altair (Aquila), Antares (Scorpio), Arcturus (Boötes), Betelgeux (Orion), Canopus (Argo), Capella (Auriga), Deneb (Cygnus), Fomalhaut (Piscis Australis), Pollux (Gemini), Procyon (Canis Minor), Regulus (Leo), Rigel (Orion), Sirius (Canis Major), Vega (Lyra).

The degree of brilliancy which is possessed by any star may be estimated by comparing it with other stars without the aid of instruments for measuring light, and an experienced observer can in this way arrive at wonderfully accurate results. In general, however, a photometric instrument of some kind is used. Photography affords a fairly trustworthy method of comparing the brilliancy of stars which appear upon the same plate, except when the stars differ in colour and therefore in photographic activity.

The Use of Photography in the Measurement of Brilliancy

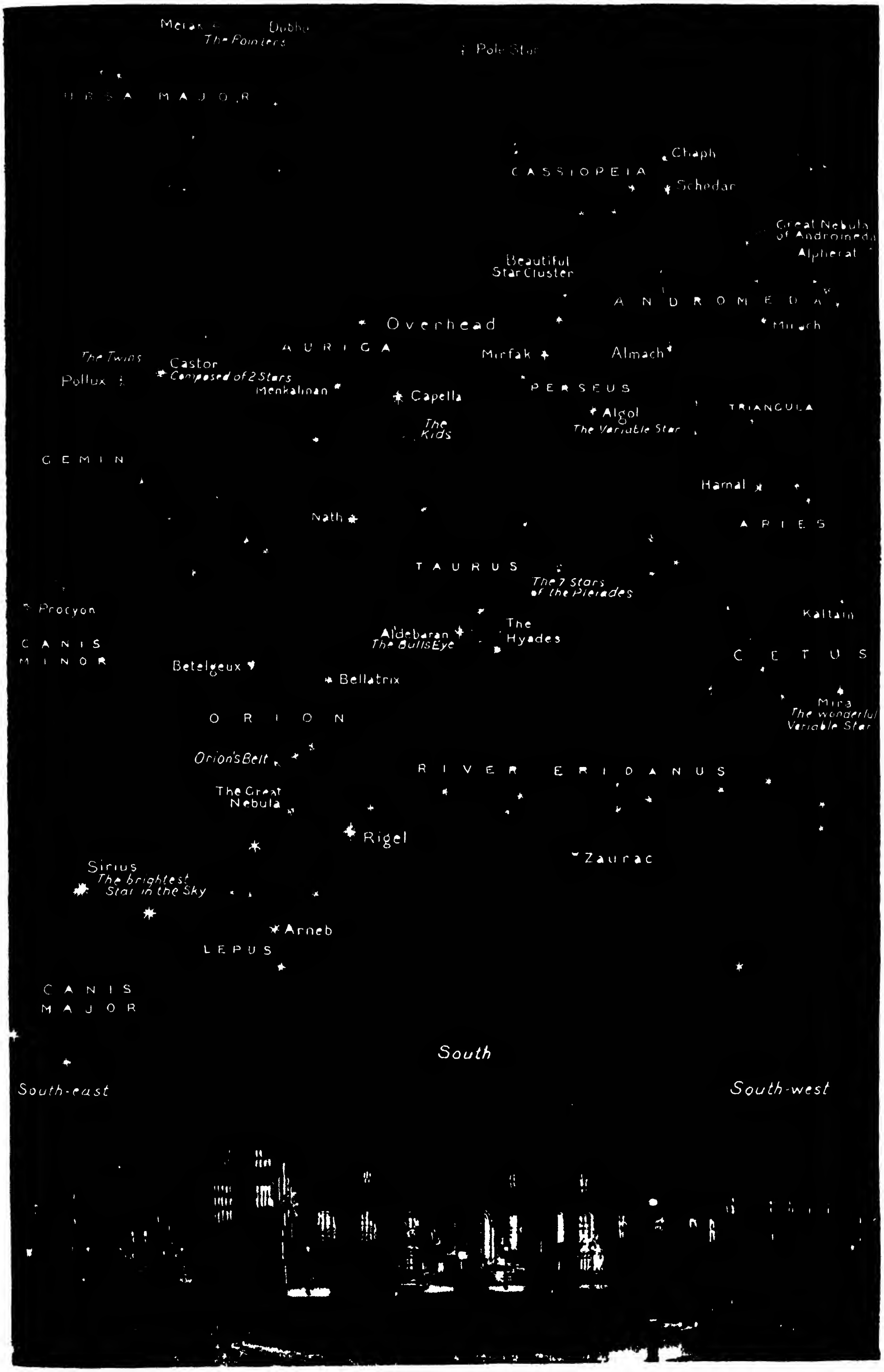
Although the stars are in effect only points of light and not surfaces, yet a brighter point of light comes out in a photograph as a larger spot of light than the spot which is made by a less brilliant point of light. More exact measurements of brilliancy may be made by sliding a tinted glass of gradually increasing thickness across the eyepiece of the telescope, and noting the precise point at which the image of the star disappears altogether; and other more complicated photometers are also used for the determination of star magnitudes.

A rough and ready way of distinguishing fixed stars from planets is afforded by the fact that the former scintillate or twinkle and the latter do not do so. Not indeed that the twinkling has its origin in the fixed stars themselves. It would be absurd to suppose that these vast and distant suns could flare up to blazing brilliancy and die down almost to darkness many times in the period of a second, or change their colour to every tint of the rainbow within the same interval. The effect of scintillation arises from unevenness in the terrestial atmosphere through which the starlight passes.

Why Stars Twinkle Most Vividly Nearest to the Horizon

Stars which are distinctly overhead do not twinkle at all; and the glancing, flashing, many-coloured appearance of their rays increases in proportion as they are low down towards the horizon, so that their light travels through a greater thickness of our atmosphere. They twinkle more vividly on cold than on warm nights, and when the barometer is high rather than when it is low, as on a clear, frosty night; yet excessive scintillation shows that there is much moisture in the air and may be taken as an indication of approaching wind and rain. A clear relation has also been discovered between the twinkling of stars, and the aurora borealis and other magnetic disturbances. Similar conditions affect both.

THE STATELY PAGEANT OF A JANUARY SKY



THE CONSTELLATIONS AND PRINCIPAL STARS DRAWN IN THEIR DIFFERENT MAGNITUDES VISIBLE FROM THE BRITISH ISLES ON ANY EVENING IN THE MONTHS OF JANUARY AND FEBRUARY

But although conditions of several different kinds tend to increase the unsteadiness of starlight, they all produce this effect by the refractive power of the atmosphere upon light. We see a star through many miles of a changeful medium, of which some portions are warmer than others and some more humid than others, so that the fine thread of light from the star to the eyes is broken and split up into its component colours by innumerable tiny movements in the air. It is a phenomenon of the same kind as the flickering and dancing movement which is often seen in objects viewed through the heated air of a summer noon. The variegated colours are most vivid in the whitest stars, because the light of white stars contains more of the colours of the spectrum than are contained in the light of yellow, orange, or red stars. By means of an ingenious instrument known as the scintillometer it has been found that the changes of colour caused by the twinkling of a star take place far more rapidly than can be appreciated by the eye, and are as frequent as from fifty to eighty in a second.

The Reason Why the Planets Shine with a Steady Light

The reason why planets hardly twinkle, if at all, is to be found in the fact that they are so vastly nearer to the eye than the fixed stars are. Therefore, though they may appear to be mere points of light, they actually present a sufficiently extended disc to neutralise the effects of atmospheric disturbances. Thus, though the rays from each portion of the disc are subject to separate twinkling, the general effect is that of a steady light, because when some rays fail their place is taken by other rays. A fixed star, on the other hand, however vast it may be, is so distant that it reveals no real disc even though examined through the largest telescope, any apparent disc which may be formed being due only to imperfections of the instrument.

We are apt to suppose that the stars which are so thickly scattered over the sky are all of one kind, all similar to one another. No impression could be more mistaken. Not only are they of many different kinds, but they show individual differences of extraordinary interest. They have to be studied one by one. Let us take as an example one small region in the constellation Andromeda, which for alphabetical reasons came first in our list. It has three bright stars of the second magnitude, arranged almost in line. One of these, named Almaach, the third in order of brilliancy, looks like any other star. In fact, however, it consists of three stars, not merely appearing by perspective at the same spot, but physically related to one another. The chief of these is an orange-coloured star, and around this there revolve a pair of stars, tinted green and blue respectively. Not far from Almaach is the radiant point of the Andromedid shooting stars. Close to it also is the vast spiral nebula, visible to the unaided eye, which is travelling toward the earth at a speed of seven miles a second. In the midst of this nebula a bright star came into being in August, 1885, and faded out into nothingness within six months.

Some of the Unexpected Sights of the Heavens Through a Telescope

Or consider the Pole Star, familiar to everyone as marking very nearly the northern point in the heavens. It is a star of the second magnitude at the end of the tail of the Little Bear. This star, whose light is nearly fifty times as great as the light of our sun, is closely related with a star of the ninth magnitude near to it, and moreover revolves once every four days round an attendant star in its immediate vicinity.

Or, again, the constellation Aquarius shows us no stars even as bright as the third magnitude, but on looking into it with the telescope we find a double star, the pair revolving round one another in about sixteen hundred years; a magnificent globular cluster of stars like a swarm of glittering bees; a pale blue nebula with rings such as those of the planet Saturn; and other equally varied celestial objects.

The Bewildering Variability of Stars, Great and Small

In Aquila, again, a constellation which is traversed by the Milky Way, we find a variable star whose light alternately gleams out and is cut off through a constantly recurrent period of seven days; and, not far from it, a new star which arose in 1899, and has gradually faded.

In Auriga, the mighty star Capella, which is at least a hundred times as bright as our sun, is found to consist of two vast luminaries revolving round one another in one hundred and four days. Another pair of stars in the same constellation revolve round one another in four days; and yet another star varies in brilliancy with bewildering and unaccountable irregularity.

In Boötes we have Arcturus, whose light is more than twelve hundred times that of our sun, and heat so great that it can be felt by sensitive instruments in our observatories—a prodigious sun moving through

space at a speed of two hundred and sixty miles a second. In Canes Venatici, the Hunting Dogs which pursue the Great Bear, the chief star appears to the unaided vision as a mere speck of light; but the telescope shows that this speck consists of two great suns, one yellow and the other lilac.

The variety of the stars is inexhaustible. Sirius, the Dog Star, in the constellation of Canis Major, is a bright white luminary which has given the name of Sirian stars to many distant suns of similar colour and constitution. Sirius was worshipped by the Egyptians as the star sacred to Isis, and was dreaded by the ancient Romans as ruling the Dog Days, or greatest heats of summer.

The lesser Dog Star, Procyon, in Canis Minor, is five times as bright as our sun, and revolves with a companion of more than half its own mass, but with little light. In Capricornus the chief star can be made out, by unaided vision, to be a pair of stars; but the telescope shows that one of these consists of two stars and the other of three, all five of them moving in close relation. It is evidently a mistake to regard our own sun as a pattern of all stars; it is of one kind among many others, and its position is perhaps isolated in an unusual degree.

The Innumerable Double Stars, and Their Complicated Movements

Double stars of all kinds are innumerable, and the periods of their revolutions vary without limit. Every constellation shows examples of them. Thus in Cassiopeia, the bright constellation shaped like the letter W between Andromeda and the Pole, we find a double star revolving once in two hundred years; and the chief star of Centaurus is a pair revolving once in eighty-one years, the two members of the pair being twenty-four times as far apart as our earth is distant from the sun. This pair, Alpha Centauri, are our nearest neighbours in space, their light taking only four years and four months to travel to the earth.

The constellation Cepheus is of interest, because its principal star will be the Pole Star after five thousand years from now. Cetus, the Whale, besides having many brilliant nebulæ, includes the wonderful star known as Mira Ceti, which was the first periodical star to be discovered; its changes recur every three hundred and thirty-one days, during which time it emerges from dimness to great brilliancy, and fades away again. Corona Australis, a small constellation on the borders of the Milky Way, includes a great star cluster, a double star of which the pair are nebulæ revolving round one another, and several stars varying in brightness through varying periods. Corona Borealis, the Northern Crown, between Boötes and Hercules, has a star which is partially eclipsed every three and a half days, another which varies greatly in brilliancy at quite irregular intervals, and three binaries, or double stars.

It is easy to learn the principal constellations with the aid of a star map and a few evenings, at different times of year, spent in studying the sky. A precise knowledge of all the groups and of their intricate boundaries is, however, unnecessary even for an accomplished astronomer.

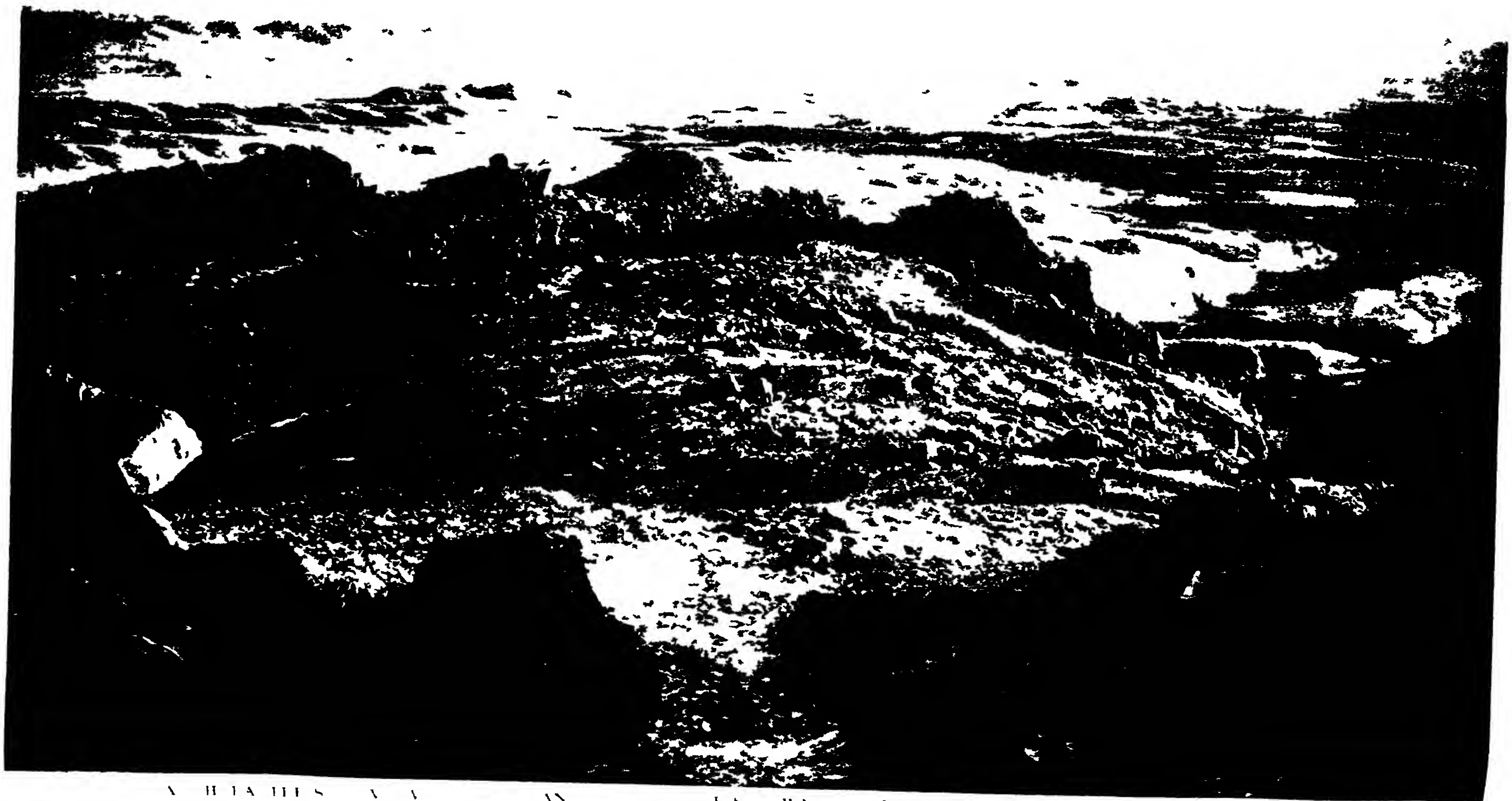
The Mapping and Cataloguing of the Stars by the Use of Photography

In former days stars were designated solely according to their constellation, and this is still done to a large extent; but the smaller stars are now known principally by their numbers in certain star catalogues, which give their right ascension and declination, analogous to the longitude and latitude of terrestrial geography, or their relation in the heavens to other stars whose situation is well known. An immense amount of labour has been given to cataloguing the stars, and the precise position and magnitude of over half a million stars are now recorded and available for reference. This work has been largely done by photography, which becomes every day more important in astronomical work. The great chart of the heavens, prepared by collaboration in various parts of the world, involves the exposure of twenty-two thousand photographic plates so as to cover every part of the sky.

The Unread Maze of Heavenly Movement that Will be Deciphered Some Day

The determination of the precise position of every star has become much more important since it has been discovered that the stars are drifting in various directions and at various speeds, and are moving in some cases more swiftly than the earth in her orbit. Thus, "1830 Groombridge" drifts through seven seconds of space every year, and several others move at speeds approaching this. Arcturus moves through over two seconds a year, and Sirius more than one second; and these speeds, though they make but little annual difference in the star's apparent position in the sky, answer to tremendous actual velocities. Moreover, many stars are combined with others in these movements, showing signs of vast systems in the universe, at whose nature we can hardly guess.

A DESERT WHERE ONE OF THE EARLIEST CIVILISATIONS OF THE WORLD IS BURIED



EARTH'S FLATTENED AREAS

The Great Rain-Deserted Plateaus, Inhospitable Deserts, and Enormous Forests of the World

DUST THAT COLLECTS YET DEFIES RAIN

BETWEEN mountains and plains come plateaus. Plateaus—sometimes called tablelands—are large tracts of flat, elevated land. Under the height of 1000 feet, elevated land hardly deserves the name of plateau, but the essence of a plateau is not so much its absolute height as its height with reference to the surrounding country; and what is a plateau in one country may be a plain in another.

Though not so impressive as mountains, plateaus play an important part in the economy of the world, chiefly through the climatic modifications they provide. Were it not for plateaus, many tropical countries would be much less healthy and habitable. In South America the civilisation attained by the Aztecs, Toltecs, and Incas was all concentrated on the high plateaus, and would not have been possible on the low forest-lands. All the great cities of Mexico, Colombia, Peru, Ecuador, are situated on high tablelands. Cuzco is 11,380 feet high, Mexico City is 7482 feet high, Santa Fé de Bogota is 8413 feet high, and Quito is 9528 feet high. Likewise, in South Africa, Johannesburg is 6000 feet high; and even in the hottest part of that continent there are plateaus, such as the plateau of Uganda and the Karoo, whose elevation provides a good, invigorating climate.

In Asia, among the Himalayas, there are many plateaus of various height and with varying flora, which serve "to bring down the north into the very bosom of the south, and to unite within a limited space all the climates of our planet and all the seasons of the year." The greatest of the Himalayan plateaus is the Pamir, or Roof of the World. Surrounded by mighty mountains and deserts, it is "self-centred, self-secure," and is as much cut off from the rest of the world as the heart of Darkest Africa. But besides the Himalayan plateaus there are many others; indeed, Asia is largely a series of plateaus, extending from Asia Minor to the Korea, and from Beluchistan to Okhotzk.

In Europe there are no plateaus to compare with the Roof of the World. In Central Spain we have a plateau 2000 to 2500 feet high, on which stands Madrid. North of Switzerland and the Tyrol there are the plateaus of Suabia and Bavaria; south of the Balkans there is the tableland of Southern Turkey. But as these plateaus are not very high, and not very well defined, they have very little climatic and geographical significance.

Africa, like Asia, is a continent of plateaus; indeed, with the exception of a few hilly parts such as Natal, and of the low lands of the coast, the Sahara, and the Nile valley, it is all plateaus together. Morocco is a plateau, Algeria is a plateau, Uganda is a plateau, most of Cape Colony consists of plateaus. A lofty elevated band of plateaus runs from the Red Sea southward and westward for thousands of miles, with profound effects on its water system.

North and South America have large areas of tableland, mostly in connection with the Rockies and Andes. Between the Wahsatch Mountains and the Sierra Nevada range is the great plateau of Utah, sometimes known as the Great Basin. Similarly surrounded by mountains are the tablelands of New Mexico, Arizona, Chihuahua, and Sonora. Bolivia, Peru, Chili, Colombia, have all plateaus, mostly between the chains of the Andes and Cordilleras. Perhaps the most remarkable plateau in North and South America is that of Titicaca, in Bolivia. This extensive plateau has a mean elevation of no less than 13,000 feet—three times as high, that is to say, as the highest mountain in England—and is so shut in by mountains that all its rain-water

is retained in its own basin, and drains into a lake in its centre, Lake Titicaca.

Plateaus have usually a small rainfall, and are sometimes almost rainless, owing to the prior precipitation of rain in the mountains that generally surround them or confront them. Thus the tableland of Tibet has a very small rainfall, since the moisture is all precipitated on the Himalayas. Madrid, which is in the centre of the plateau of Castile, has a rainfall of only 10 inches; while Coimbra, in about the same latitude on the same peninsula, has a rainfall of over 100 inches. The South Africa Karoo has a rainfall of only a few

ON THE CATTLE RANCHES OF THE FLAT COUNTRY OF ARIZONA

inches, and the Kalahari plateau is an almost rainless desert.

It is, in fact, lack of rain that renders a plateau of any considerable height possible. With a heavy rainfall, a plateau would soon be rendered rugged and irregular by the erosion of rivers and by the direct denudation of the rain. Many countries and districts, such as the fjords of Norway, were originally plateaus, and were cut up in time by rain and rivers.

Plains must be considered with plateaus, since the main difference between a plain and a plateau is a difference of level. Plateaus, as we have said, are flat stretches of land above 1000 feet high; while plains are similar flat stretches of land which do not attain a height of 1000 feet. The largest plain in the world is the plain of Eurasia, which stretches across the north of Europe and Asia from the centre of England to the east of Siberia. It is bounded on the north by the Arctic Ocean, and on the south by France, Spain, Germany, and the plateaus of Asia. This immense plain is divided into an eastern and a western half by the Ural Mountains. So level is the plain that except for this dividing ridge it would be possible to drive a motor-car, at high speed, from one end to the other.

Another great plain extends along the eastern side of North America, including the valley of the Mississippi. Another great plain is the Amazon basin, which presents the gentlest landslope in the world. Yet another runs down the centre of South America, bordering the base of the Andes and forming the fifth of the whole continent.

Plains in most instances are sedimentary strata, and have been raised level from the bottom of the sea, and consist usually of strata which have been deposited in quite recent times. In some instances, though the surface is level, the strata are not horizontal, and the flatness of the surface

is due to submarine erosion. But not all plains are sea-plains; many, such as the delta of the Nile and the lowlands of Holland, have been deposited by rivers.

Like plateaus, most plains have a small rainfall; otherwise, if any height above the sea, they could hardly preserve a level surface. Many of the great plains, indeed, such as the Sahara and the tundras of Siberia, are deserts. Yet though aridity is a fairly common characteristic of plains, it is by no means a constant characteristic, for the plains of Mesopotamia and Egypt are some of the most fertile land on the face of the globe, and the plain of the valley of the Amazon is clad in luxuriant tropical vegetation. Many plains have special local characteristics, and have therefore received special names. A few of these plains we may now consider.

Certain plains in Europe are known as *landes*. The landes of Gascony are marshy plains in Gascony, Le Gironde, and Lot-et-Garonne, of submarine origin, which stretch flat as a pancake. So flat are the landes that between La Mothe and Labouheyre the railway runs perfectly straight for a distance of twenty-eight miles. "All round," writes Réclus, "within the limited circle which is surrounded by the level line of the horizon, nothing is to be seen but a thick underwood of brandes and various other kinds of heath, springing up to the height of a yard or two above the ground. During their flowering time these plants mingle a light shade of pink with their delicate green, but they appear everywhere bristling with a number of heath-branches, leafless, and black as if charred in a fire. In other spots tall ferns have taken possession of the ground, filling the air with their penetrating odour. Further on we come upon large patches of furze and broom, which flower together in the spring and cover the plain with an immense veil of gold. Mosses, grasses, and briars grow together along the edges of the paths; water-lilies and other aquatic plants repose quietly on the surface of the muddy pools; tufts of rushes and sedge spring up in the spongy earth around the water. And this is all.' So marshy are the landes that shepherds herd their flocks on stilts. When Réclus wrote, the landes of Gascony extended for nearly 2,500,000 acres, but since that date they have been rapidly reclaimed.


SHEPHERDS ON STILTS IN THE LANDES OF GASCONY

Even more extensive than the landes of Gascony are the landes which are found in Holland and the North of Germany. In

Holland there are millions of acres covered with spongy peat-mosses. In Hungary and Central Russia, instead of landes, we have the plains known as steppes. In Hungary the steppes are simply prairies of natural grass and meadow-flowers, over which roam herds of oxen and horses. In Central Russia the steppes are enormous, and the Tchernozom steppes alone extend over more than 197,500,000 acres. The greater part of this area is simply grass, but much of it is under corn. The soil is very rich, and hardly to be surpassed for corn growing. South of the Tchernozom steppes, in the neighbourhood of the Caspian Sea, there are barren steppes of white sand and reddish clay where nothing but a few shrubs will grow. For a distance of 310 miles in a straight line only one tree – a tree of the poplar species – is to be found; and such veneration have the Kirghizes for this tree "that they often go several miles out of their way to pay it a visit, and each time they hang an article of their clothing upon its branches. From this custom the name of singderishhagatch, or rag-tree, has been given to the desert poplar."

The low plains which are found in the north of Russia and Siberia are known as *tundra*. They are some of the most desolate tracts of country in the world. In the winter they are covered with snow; and in summer they are converted into a boggy, bird-breeding land, covered thickly with reindeer moss and whitish lichen.

In North America plains are extensive. Along the Arctic border of North America are barren stretches like the tundra plains of Asia, but most of the New World plains are covered with vegetation. In the basin of the Mississippi the plains are covered with forests interspersed with grassy tracts. In Canada and in the Western States of North America there are vast stretches of undulating grassy land known as prairies or savannahs, but soon these will all be brought under cultivation by the emigrating millions of Europe.

In South America, in the basins of the Amazon and other large rivers, we have plains chequered with forests and grass lands like the plains of the Mississippi basin, and we have also large tracts of grass country. In South America the grassy plains are known as *pampas* or *llaños*, and in the warmer zones mimosas and other shrubs grow among the grass. The llaños of Colombia are remarkable for the manner in which they are alternately desert land and pasture land. Before the rainy season, the soil is dried up and all vegetation perishes and the llaños become a veritable desert; then all at once the storms of the rainy season inundate the soil, multitudes of plants shoot from out the dust, and the immense yellow expanse is transformed into a flowery meadow. The most remarkable plain in South America is the Argentine Pampas, which stretches for a distance of about 2000 miles between

A TYPICAL SCENE ON THE LANDES OF NORTHERN GERMANY

Brazil and Patagonia, and includes an area of at least 500,000 square miles. On the great Pampas of the Argentine Republic pasture millions of cattle; they are probably the greatest grazing grounds in the world.

Besides these landes, tundras, prairies, llaños, and steppes, we have the great deserts, properly so called, which are sometimes plains and sometimes plateaus. The best-known desert plain and perhaps the most typical desert is the Sahara, which extends across Africa from the Atlantic to the Red Sea, a distance of 3100 miles. The breadth of this desert zone averages 600 miles, and altogether the desert covers an area equal in size to two-thirds of Europe. The mean height of the desert is 2000 feet, and it might, therefore, be considered a plateau rather than a plain except for the fact that there is no low ground to contrast with the general level of the desert sands, and that above the desert, here and there, there are elevated tracts which are themselves plateaus with reference to the desert.

About the middle of the Sahara a group of lofty mountains divides it into eastern and western portions, and the western portion is often distinguished as the Sahal. The Sahal is a wilderness of sand, blown by the winds, now here, now there. In the west the sand is driven into the ocean and actually encroaches upon it. To the south it is driven into the Niger and Senegal in such quantities as gradually to alter their course. At Cape Bojador and Cape Blanco are the highest sand-dunes in the world. A constant stream of sand is blown from the north-east to the south-west, overwhelming oases, and making and unmaking dunes as it proceeds. So torrential sometimes is the stream of sand that it is said that whole caravans are sometimes buried under it.

The East Sahara is also a waste of sand, but numerous plateaus of rock and clay, and a fair number of mountains, break the monotony of the sandy plains. As in the Sahal, there is a steady drift of the sand towards the south-west. One would think that soon the desert would be swept bare of sand, but the same winds that sweep away the sand break up the sandstone of which the desert floor is composed, and so keep up a constant supply of sand. The Sahara is not a flat plain lifted from the sea, but a land of sandstone hills which has been sand-papered level by wind and sand, much as diamonds are ground down by their own dust. When one looks into the future, one sees that the consequences of this wind-erosion must eventually be very extraordinary. Inch by inch, foot by foot, the sand-laden winds grind away the sandstone surface of the desert, and blow it into rivers and into the sea. Year by year the mean altitude of the desert decreases, and the time will come when it is planed away to a height below sea-level. Even at present there are parts of the desert in Algeria and Tripoli which are below sea-level; and in

THE VAST SEA OF SAND THAT FORMS THE DESERT OF SAHARA

EARTH'S GREAT BELTS OF BARRENNESS

THE PRINCIPAL FORESTS, DESERTS, PAMPAS, LLANOS, AND GRASS-LANDS OF THE NEW WORLD

PARCHED BY HEAT & CONGEALED BY COLD

THE PRINCIPAL FORESTS, DESERTS, STEPPES, AND TUNDRAS OF THE OLD WORLD

time a great part of the desert will be scooped out below sea-level. Then all that will be required is access of the sea, and a great part of the Sahara will be flooded with sea water. The consequences to climate and commerce of such a flooding would be enormous and far reaching. The heart of Africa would be rendered more accessible, and the climate of the desert in parts near the inland sea would be rendered more humid and greatly modified.

The suggestion has often been made that those parts of the Sahara which are at present below sea-level might be flooded from the Mediterranean by means of a

CATTLE PUNCHERS RIDING OVER THE SHIFTING SANDS OF THE UTAH DESERT

canal but whether such a scheme be feasible we cannot say. So hot and dry is the Sahara as to be almost quite uninhabitable in far the greater part of its extent. The lack of water is fatal to most forms of life. Even the fly and the flea cannot survive the heat and the drought, and the only creatures that inhabit the desert are scorpions, lizards, vipers, and ants.

Nor is only the climate of the Sahara hot; it is also subject to extreme annual vicissitudes of temperature. The temperature in the shade runs up at times to 136 deg. Fahr. or so, but it also falls at times to 15 deg. or 20 deg. Fahr., and most parts of the desert have experience of frost in the course of the year. These extremes are due to the dryness of the air, and that dryness also produces a rapid fall of temperature at night, since the heat rapidly radiates away from the heated earth through the dry air.

The only redeeming feature of the Sahara are the oases which are dotted over it here and there. Wherever water rises from the earth or reaches the desert as a stream from the hills, there a little green island is created. In the Sahara these oases are quite numerous, and luckily they are not scattered irregularly, but arranged mostly in a line right across the desert, so that it is possible to journey by stages for great distances over the sand. The fertility of the desert soil is amazing; it requires only water to make it blossom like the rose. The special tree of the oasis is the date-palm, and it is interesting to note that the date is perhaps the most nourishing of all natural foods. Nature, in the extremely limited amount of soil at her disposal, has taken care to grow a very concentrated food. The date palms are the wheatfields of the desert, and a few oases planted with date palms will nourish quite a large population of Arabs; but dates are not the only food that the soil of the Sahara will grow

THE FINE NATURAL FRUIT OF THE DESERT

THE MARKETING OF DATES WHERE THEY ARE GROWN—IN NORTHERN ALGERIA

DATES AS THEY GROW ON THE PALM TO ORDER IN CALIFORNIA

Below the date-tree's fan of leaves, as Réclus describes it, "are thickly growing clumps of apricot, peach, pomegranate, and orange-trees, their branches loaded with fruit, and vines intertwining round the trunks. Under the shade of this forest of fruit-trees ripen maize, wheat, and barley, and, lower still, the modest trefoil fills up the smallest intervals of the soil which is capable of irrigation." Unfortunately, the supply of water to the oases is capricious; at times there is a dearth, and at times there may be sudden and violent floods, which may wash away the trees and crops.

AN ENCAMPMENT OF BEDOUIN ARABS, THE INHABITANTS OF THE DESERT

There can be no doubt, however, that this unsatisfactory state is capable of being remedied by a careful system of irrigation. Water from the natural fountains and streams might be stored and given forth regularly and economically as required, as is done at some of the villages on the African Karoo. Further, the supply of water might be largely augmented by artesian wells, for in many, if not in most, tracts of the Sahara plenty of subterranean water can be tapped. Between 1856 and 1876, the French sunk 156 wells in the desert in Constantine, and got enough water to nourish 200,000 palms. By a little systematic enterprise on these lines, the great tracts of the deserts might be made fertile land, and the whole climate of the Sahara might be altered. Indeed, there are signs that the Sahara was once much more fertile, and that a great river ran through Algeria. If the Italians have sufficient enterprise to flood that part of Tripoli which lies below sea-level, and to sink artesian wells in the surrounding country, they may yet recoup themselves for the blood and money they seem to have wasted.

Across the Red Sea lie the Arabian deserts, which in many respects resemble the Sahara. The most extensive and desolate region is the Dahna desert, in the south-east. Some of the smaller deserts in the north and east, knows as the Nefuds are remarkable for the depth of the sand which covers them. In places the depth amounts to 500 feet. Beyond Arabia, the deserts still continue eastward across Afghanistan and Beluchistan, to China and Siberia, as an almost continuous chain Finally, between Siberia and China stretches for 1850 miles the great desert of Gobi or Shamo, second only in extent to the Sahara and more than equalling it in desolation and aridity. It is a waste of sand and sandhills

with hardly any vegetation or a single tree. From the Sahara it differs in one essential particular—it is swept by Polar winds, and is not hot, but very cold.

In South America there are numerous deserts, most of them high plateaus. In the "Great Basin," which we have previously mentioned among the plateaus there, is the desert of Utah. It is an immense stretch of dry clay, sometimes white with crystallised salt, without a single river or spring, and inhabited only by myriads of lizards. At the time of the Californian gold rush, thousands of men and cattle died of thirst when trying to cross this desert. At one time, indeed, a traveller could tell the pathway at night by "the sound of the skeletons crushing under the feet of his steed."

On a high plateau between the western slope of the Andes and the Pacific is the salt desert of Tamarugal. So thick is the salt deposited on the ground that the houses of the workmen are sometimes made of blocks of salt. From this salt desert and the surrounding country, millions of tons of saltpetre have been obtained. The desert of Atacama, the largest desert in South America, also occupies a plateau between the Andes and the Pacific. Like the desert of Tamarugal, it produces salt and saltpetre, and in addition is covered with large quantities of guano.

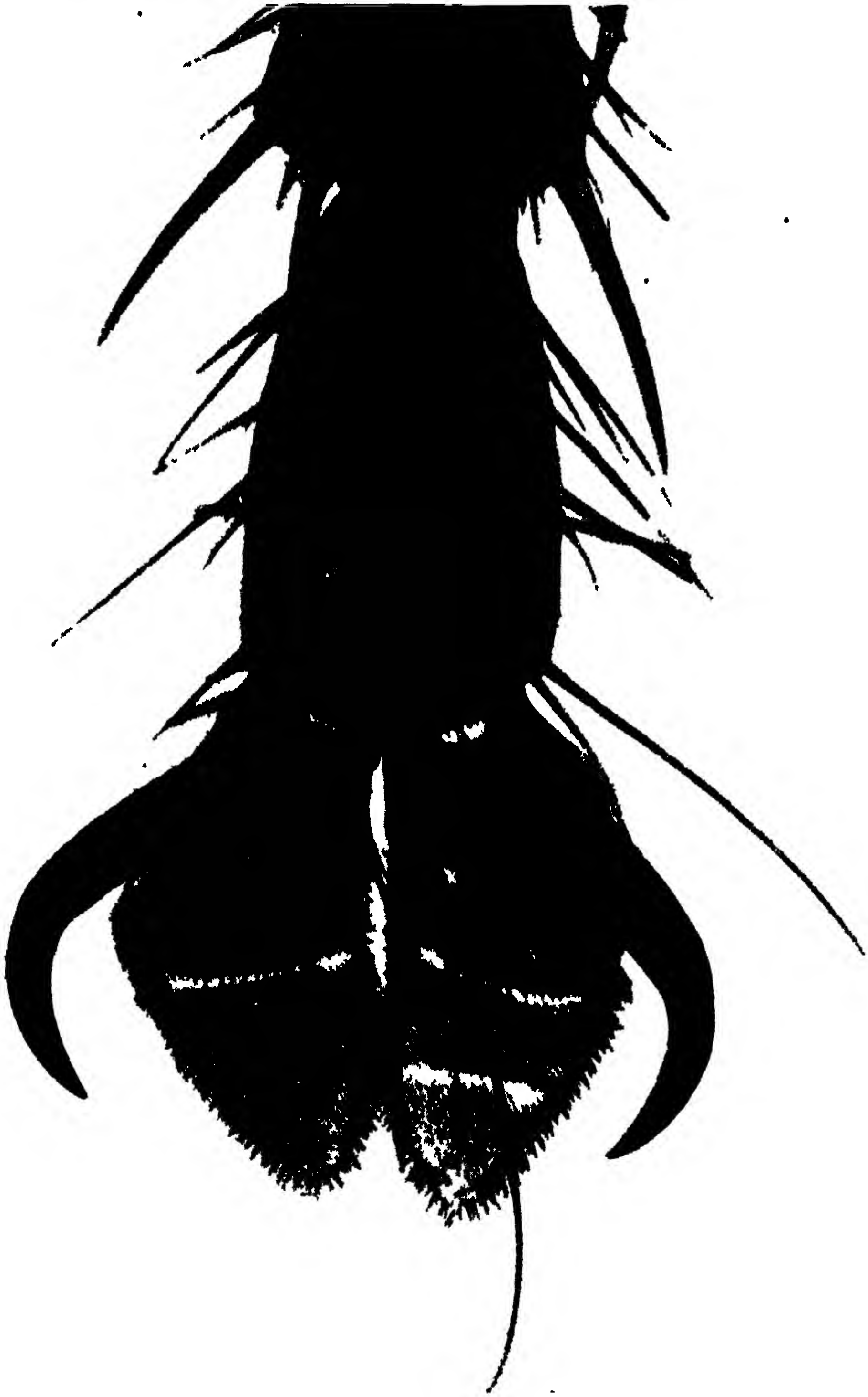
There still remain to be mentioned the great deserts of Australia, which occupy a large part of that island continent. The whole of the centre of the continent is a stretch of reddish clay, with patches of scrub here and there. Useless as deserts in most instances seem to be, we must not forget that they are of great though rather obscure service in several ways. Though they may be rainless in themselves, they are great rain-makers and rain-distributors; for, without the dust in the air, clouds could hardly be formed to carry the rain from land to land, and the dust in the air is certainly largely replenished by deserts. Again, the hot deserts perform an important part in the circulation of the atmosphere, for their bare heated surface, constantly changing its temperature, causes perpetual currents of wind in various directions. Yet, again, the dry, hot deserts have permitted the accumulation of guano and nitrates, without which the wheatfields of the modern world could hardly exist.

A FOREST SCENE IN CENTRAL AFRICA

A considerable portion of the surface of the earth is covered with bush and forest. Given sufficient rainfall, there are usually trees. Where the rainfall is meagre, only bushes may grow, but where it is more plentiful forest trees soon appear. The thickest forests occupy the equatorial zone, for here there is both a plentiful rainfall and abundance of warmth. Under such circumstances, the trees and undergrowth form almost impenetrable forests. Great tropical forests are found in Brazil, in the Congo, in Nigeria, on the west coast of the Malay peninsula, and in India.

In temperate zones forests are not so luxurious and dense, but in many parts they are quite extensive. Great forests are found in Scandinavia, and round the lakes of Canada, and in British Columbia. At one time a larger part of Europe was covered with forests, but they have mostly been felled. Where the climate is fairly warm, a great variety of trees is found—oak, beech, elm, ash, lime, chestnut, sycamore, poplar, willow, etc.; but in colder climates only a few hardy trees, such as pines, firs, larches, and birches. We have already pointed out the relationship between trees and rain.

A CARRIER OF DEATH-DEALING DISEASE



THE FOOT OF THE COMMON HOUSE FLY, HIGHLY MAGNIFIED, SHOWING ITS CLAWS, PADS AND BRISTLES, UPON WHICH DISEASE BACILLI ARE CONVEYED TO MAN'S FOOD MATERIALS

This photograph is by Mr. J. J. Ward. Those on pages 3560 and 3561 are reproduced from Sir Rubert Boyce's "Mosquito or Man" (John Murray), and those on pages 3564 and 3565 are by Dr. E. J. Spitta

THE CONQUEST OF DISEASE

The Discovery and Arrest of the Spread, by Mosquitoes, Flies, Fleas, and Ticks, of Dreadful Epidemics

THE EARTH MADE HABITABLE BY SCIENCE

FOR countless ages the mosquito has barred Africa from civilisation, which otherwise would most certainly have flowed into the "Dark Continent" from its home in Asia sooner than into Europe. But malaria is not the only reason for which man and the mosquito are at enmity, though it is a million times more than sufficient. We now know that there is, at any rate, one other disease, terrible in its fatality and in our impotence against it until the present century, which is conveyed from man to man by the mosquito, as malaria is.

In the case of malaria we could preface our discussion with a definite statement as to the actual cause of the disease—an animal parasite which lives in the blood of the patient. In the case of yellow fever we are in the very extraordinary position of being unable to describe the parasite, though we can control the disease, and though no one can have the slightest doubt that the disease is caused by a parasite which the mosquito conveys. Ten or fifteen years ago a certain *bacillus icteroides*—the bacillus of yellowness—was described in the bacteriological text-books as the cause of yellow fever, but we are now agreed that this bacillus is not the cause of the disease. So many good eyes and microscopes have been used in searching for the parasite, during the last decade, by men whose quality is proved, for they have found out everything else of material importance, that there are many who believe the parasite of yellow fever to be ultra-microscopic—a living organism so minute that the microscope cannot reveal it. Whether or not this will prove to be the case we cannot yet say. But the disease-agent is conveyed by a known mosquito.

Half-way through the nineteenth century Beauperthuy rightly guessed that mosquitoes convey disease. He was right as regards malaria, and he was more than ever right as regards yellow fever, for he actually named the particular kind of mosquito—not an anopheline, as in the case of malaria—which alone conveys the disease. In 1881, a famous pioneer, Dr. Charles Finlay, also incriminated the right mosquito, declaring that it conveys the then and now unknown infection *from man to man*. Finlay was right, but for long before and after his time this question of the transmission from man to man was the puzzle. For, in fact, there was no evidence that the disease is contagious. Some brave students had tried to infect themselves—or, rather, to demonstrate that they could not be infected—by contact with clothes, and so forth, which might be expected to convey the contagion; in no case was the disease transmitted. And yet no one could observe the facts of the disease at large without inclining to the view that the infection spreads "from man to man."

In this country we appointed a Commission to study the disease in order to decide what the quarantine laws should be. The Commission reported against quarantine, as useless, and declared that "in an epidemic the most rigid seclusion affords no protection, that great success attends removal to a non-infected district, that the exciting cause, whatever it is, is local and endemic." Here and there observers were to be found who said that the disease is not contagious, though the infection does somehow get from the sick to the sound; and some of them remarked on the curious fact that an interval of time seemed to be required, somehow, somewhere, before the unknown could pass from one man to another. Why this interval of time, and where was it spent?

Following the order of our knowledge, let us briefly look at the facts of yellow fever,

or "Yellow Jack," as they were known at the end of the nineteenth century. Like malaria, the disease has played a great part in history. The buccaneers of long ago, and, later, our regular troops, found in it an enemy, "when we engaged in conquering in the West Indies and on the Spanish Main, which time and time again swept our pioneers and soldiers away just as so many flies." In 1840, our Secretary for War wrote to Georgetown, Demerara, asking "why in a few months 69 per cent. of all the white troops had perished" Prescott, the great historian of the New World, wrote of this disease, that the moment a town was founded or a new commercial centre created, an explosion of the latent malignity of the poison in the air was certain to occur. The disease was known to the Aztecs, and according to Humboldt it existed as early as the eleventh century. The followers of Columbus were cursed by it at San Domingo; and Columbus had to write to the King of Spain about the disease, which he attributed to "peculiarities in the air and water" in the new country. The "Pest of Havana," described as early as 1620, was doubtless yellow fever, which is believed to have carried off one-fourth of the population of that town for centuries. But now there has not been a case, let alone a death, in Havana for years.

The Work of United States Army Surgeons in Mastering Yellow Fever

The new era began, thanks to the Spanish-American War, in 1900, when the United States sent certain Army surgeons to Cuba to study the disease. Influenced by the theory of Finlay and the work of Ross upon malaria, they began at once to search in the right direction. Dr. Lazear, one of the Americans, died of the disease, as did Dr. Myers, sent out from Liverpool. The various workers, between them, proved that the clothes and excretions of the patients were not infectious—by sleeping in the patients' clothes, upon their contaminated bed-linen, and so forth; they proved that the blood of the patient contains the unknown agent only five days after he is infected, and that if he be then bitten by one particular species of mosquito, the "Stegomyia calopus," and by that alone, after ten to twelve days, but not before, that mosquito becomes capable of conveying the disease to any healthy man whom it chances to bite.

And now, of course, we know where we are. All manner of agents have been blamed in the past, from droughts and floods and "pestilential swamps" to the stone ballast of ships, thousands of tons of which have been disinfected or thrown into the sea. Before the new work in Havana, the American Army doctors had already transformed, in many essential respects, the sanitary conditions of the city, and had freely used the ideas of Pasteur and the practice of Lord Lister in the form of antiseptics and disinfectants, in order to arrest the yellow fever. Nothing affected the disease in the least. It only ceased after employing methods directed against the mosquito—viz., fumigation, screening, and destroying the breeding-places of the larvæ. The following is a summary of the new knowledge, given by the late Sir Rubert Boyce, who himself contributed effectively to it:

Summary of New Knowledge Gained Respecting the Spread & Prevention of Yellow Fever

1. Man suffering from yellow fever after the fifth day is the *reservoir*.

2. From this reservoir one species of mosquito, the Stegomyia calopus, becomes infected, and after the tenth day becomes the insect *carrier*, or transmitting agent of the disease.

3. The reservoirs and the carriers are both necessary for the spread of the disease.

4. Method of attack:

(*a*) Prevent entry of reservoirs (quarantine measures, etc.).

(*b*) Exterminate the carrier (anti-adult mosquito measures, screening, fumigation, etc.; anti-larval measures, control of water supply, oiling, drainage.).

The Stegomyia calopus, the larval and adult forms of which are here shown, has long been familiar in the tropics. It is a domestic mosquito, like our own domestic fly, and is often called the "cistern mosquito," because it breeds in cisterns and such places, but *not* in the natural pools and puddles which are favoured by the malarial mosquito. The female alone sucks blood.

The Extraordinary Effects of American as Compared with Spanish Control

The Spaniards did nothing for Havana, except in so far as their ancestors contributed to the discovery of America, and thus to the American control, which began when yellow fever had been causing an average number of two deaths every day in Havana since 1853. But now the disease has been annihilated. In April, 1909, when the "Bulletin of Public Health and Charities of Cuba" was published, the republic was declared "free from small-pox, yellow fever, and bubonic plague." In

New Orleans, with its sixty to seventy thousand water-butts, the disease was rife. There Sir Rubert Boyce went to fight it in 1905. Posters were issued encouraging the citizens to burn sulphur in order to kill mosquitoes. The result of his work and that of others is here described in his own words. "Thus an outbreak which in previous years would have developed into the usual awful epidemic was in a few weeks, at a comparatively small cost, completely stopped, and that in the face of a dense population, open drains, and a sultry summer." From New Orleans Sir Rubert went on to Belize, in British Honduras, at the request of the Colonial Office, and his work bore similar fruit there.

But the most remarkable and important case of all, for the future history of mankind, is the campaign against the stegomyia in the Panama Canal zone. The plan of campaign was begun there from the moment that the Isthmian Canal Commissioners took over its administration. It consisted in rigorously prohibiting the keeping of stagnant water, and in screening, house-to-house inspection, and the infliction of fines if larvæ were discovered.

The Complete Extermination of Yellow Fever where it had Meant almost Certain Death

The disease has been banished; and as early as 1908, Colonel Gorgas, to whom Havana also owed so much, could write that "it is now more than three years since a case of yellow fever has developed in the isthmus, the last case occurring in November, 1905. The health and sick rates will compare favourably with most parts of the United States." The verdict of history upon this tremendous enterprise, which has now practically reached its successful completion, will be that the essential difference between the disastrous and appalling failure of the French in the nineteenth century and the success of the Americans in the twentieth was due to two factors and two alone—first, the anti-mosquito measures by which malaria and yellow fever were banished from the zone; and second, the absolute prohibition of the sale of alcohol for an area extending for several miles on each side of the canal throughout its entire length.

It is probable that another tropical fever, called dengue, is spread by another mosquito called the Culex fatigans.

We turn now to another group of insects, widely summed as "flies," and to a terrible disease, for which no quinine nor any known drug yet avails, and which is popularly called the "sleeping sickness," in reference to the increasing stupidity and dulness of the patient, due to the attack of the disease-poisons upon the brain. First, as to the causal parasite, which here, as in the case of malaria, and as not in the case of yellow fever, is definitely known. Like the malaria parasite, this belongs to the animal kingdom. It is a microscopic creature, with a somewhat spiral, ribbon-shaped body, and is hence known as a trypanosome. Certain forms of trypanosome have been known for more than forty years as blood-parasites of several of the lower animals. But it was not until the years 1901 and 1902 that a trypanosome was proved, by Sir David Bruce and by Dr. Castellani, to be the cause of sleeping sickness, which is now technically known as "trypanosomiasis."

The Search for the Cause and Cure of the Sleeping Sickness

This most fatal malady is apparently of new development in Africa, on any large scale. The development of the continent by trade, and the movement of large bodies of natives from point to point, have led to the spread of the disease on an appalling scale. Whole communities on the Congo and elsewhere have been wiped out, and in the Uganda Protectorate there have been hundreds of thousands of victims. But all real knowledge makes easier and quicker the acquisition of more knowledge—"it is only the first step that costs." The work of Ross, following upon that of Pasteur and Laveran and Manson, had given us the key to malaria, and had incidentally shown how much may be learnt regarding human disease by the study of disease in the lower animals.

The Campaign against the Fly Diseases of Horses and Cattle

The distinguished investigator who is now Sir David Bruce had already shown that the fly-disease of horses and cattle known as nagana in Africa is conveyed from one animal to another by the bite of a species of tsetse-fly which is known as the Glossina morsitans—the "biting Glossina." Then, having found the trypanosome in sleeping sickness, he had to seek a fly, probably a tsetse-fly, which might convey the parasite in this case also.

The "carrier" was soon found in the form of the particular tsetse-fly which is known as the Glossina palpalis. Only where that fly is found do we find sleeping sickness, just as we find malaria only where there are anophelines, and yellow fever only where there is the stegomyia.

As in the latter case, it was further proved by Bruce and others that the trypanosome uses the tsetse-fly as a true host, in which it passes part of its life-cycle. It is not that the fly merely happens to have some of the trypanosomes hanging about its proboscis, and so may infect a fresh person. On the contrary, a period of from two to three weeks is necessary before the development of the trypanosome in the fly enables it to infect a new human being. This is not a question of zoological interest merely. It means that *any* biting fly, which happens to bite a patient with trypanosomes in his blood, will not avail to convey the disease. As in the cases of malaria and yellow fever, a specific insect host is required for the specific parasite; and just as the extermination of malaria or of yellow fever would be well-nigh hopeless if every common culex mosquito could convey it, so here we realise that we may succeed because only one particular insect need be attacked, and if we examine its habits we shall find a vulnerable point.

The plan of campaign in this case has been, and is, to attack the fly less in its adult than in its larval stages. Its breeding-place is the strip of ground-bush extending for not more than thirty yards from river-banks. Here the young larvæ find the humidity and shad they require. Find the exact facts in t is fashion, and proceed to burn down the ground-bush, and the flies will be interfered with. Here, as in the previous cases, precise knowledge narrows the limits of what is necessary. As Sir Rubert Boyce said, " It is not necessary to cut down forests, any more than it is necessary to drain lakes and run rivers dry in anti-malarial operations. All that is essential is to go for the chief breeding-grounds round man, and to let the forests take care of themselves." The late Professor Koch satisfied himself that certain wild animals, such as the crocodile, are preyed upon by the glossina, and that it would be worth while to attack them. Hunters of big game have, on these grounds, asked for relaxation of the restrictions at present placed upon their sport. But experience has shown that the very indirect method of attacking, say, crocodiles because the tsetse-fly may occasionally suck their blood is quite superfluous, even if it were really useful.

THE LARVA OF STEGOMYIA CALOPUS

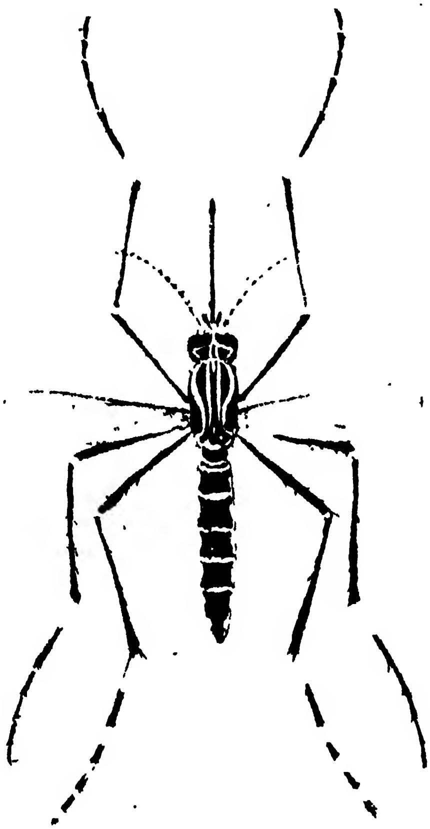
Much can be done in other ways, as by avoiding the bite of the fly, and also, perhaps, by the use of drugs. There seems little doubt that certain organic combinations of arsenic have the power of killing the trypanosomes in the blood. Such combinations are " atoxyl," and probably the " 606 " or salvarsan later introduced by Professor Ehrlich for attacking another form of animal parasite, not very distantly related to the trypanosome, which has been proved to cause the disease called syphilis. These therapeutic experiments are no doubt very interesting and may often have prolonged life, but their scope is limited. For one thing, the trypanosomes learn to take refuge in the nervous system; and though they may be killed in and banished from the blood, some still remain. Further, after a period of dosage, the trypanosomes which have not been killed, or some of them, begin to acquire a resistance to the arsenical drug; and when they have acquired this immunity against the poison we can no longer arrest their development in and ultimate destruction of the patient's body.

What we need, above all, is therefore the radical method of destroying the insect species without which the disease cannot spread. This is now being done. All the nations which possess Central African colonies are engaged in the work. We have our own National Bureau in London, established under the auspices of the Colonial Office; and it was one of the last suggestions of the late Sir Rubert Boyce that similar bureaux might be established in connection with the other tropical diseases. Where men are face to face with great and dangerous facts which are novel and must be mastered, they waste no time in argument, but act, just as we should do

in this country if tuberculosis had been unknown last year and were killing us at the rate of sixty thousand a year now. So the men in Uganda set to work as soon as the facts were known, and they have controlled the disease.

This involved burning bushes, removing 21,000 natives from the islands of Victoria Nyanza to inland districts where the tsetse did not exist, and many other measures of a drastic and extensive kind. No one argued whether or not it was worth doing, whether the disease would not weed out the inferior stocks, and so forth. Sir David Bruce and his colleagues found the facts, and the white men and the native Government gladly acted upon them.

But flies of one kind and another are very common. May they not be responsible for other diseases besides those which the tsetse-fly conveys to man and various lower animals? Something has already been said of malaria in India. Let us now consider the plague which has raged there in many epidemics for some years past, having found its way south from its ancient endemic home in China. It has been known for many years that Oriental plague, bubonic plague, the "Black Death" of history, is due to a bacillus which is known as the bacillus pestis, and against which all drugs hitherto tried have been unavailing. This is the disease which has in the past visited our own islands, as in the Plague of London, and which has paid frequent visits to them since, always to be arrested at or near the port of entry. As far back as the time of the Boer War observant doctors were talking about the fly as the conveyer of typhoid; and in 1906 a Plague Commission, sent afresh to India, and having the new knowledge discovered by Manson and Ross and Bruce in its head, began to look for an insect as the carrier of the plague bacillus. They found the insect, in the shape not of a fly, but of a flea, and especially the rat-flea. We are definitely to discriminate between this and previous cases, for a bacillus has no such complicated life-cycle as the parasites we have lately discussed, and needs no intermediate host, as they do. Thus a bacillary disease may be communicated in many ways; and plague, for instance, when it attacks the lungs—the deadly "pneumonic plague" lately seen in Manchuria—may be conveyed by the sputum, like tuberculosis or influenza.



STEGOMYIA CALOPUS—THE CARRIER OF YELLOW FEVER

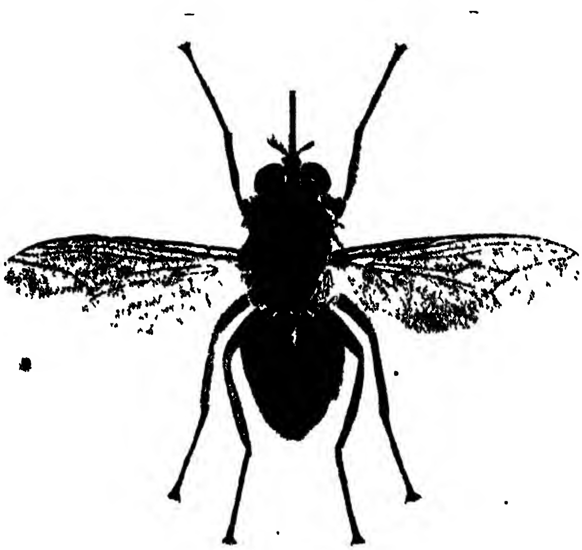
The chief agent in the conveyance of this disease—which does not usually affect the lungs and so cannot be spread by the sputum—has been found to be the rat-flea. This insect bites both man and the rat. When it bites a man who suffers from plague, the bacilli thrive in the flea, and may be passed by it into the blood of another man or of a rat. Or the rats may be the first sufferers, and then the flea conveys the bacilli from them to man. Epidemics of plague among rats often precede those in man; and dead and sick rats have for long ages been suspected in countries where plague is common. Study of the recent cases of plague in East Anglia showed that other animals besides rats may sometimes be affected. But the rat and the rat flea are the great enemies of man in regard to this disease. There is some reason to suppose that only certain kinds of rat can be affected, and that the coming of the big brown rat from Norway into these islands, dispossessing the smaller black rat, which is supposed to be alone susceptible, may have put an end to endemic plague in this country, but this is somewhat dubious.

At any rate, we require to wage a special war against the rat. A recently formed Society for the Destruction of Vermin had to suspend operations for lack of support, but the idea has "come to stay." Already

the sanitary authorities at our ports, especially in regard to ships coming from countries where plague exists, take steps to destroy the rats on such ships, or to prevent them from coming ashore. In Liverpool the rats are systematically examined by bacteriologists throughout the year. The increasing stream and variety of commerce, drawing the world closer together, is also making it far easier than in the past for diseases like plague to be spread and sown afar. If plague had as often been brought to our shores a century ago as it is nowadays, our ancestors would scarcely have escaped. But now, when it reaches Hull or London or Glasgow or Liverpool, it scarcely gets any further, because exact knowledge, applied to the problem, bars the way.

In India the plague is formidable and tragic. European science and humanity have not been entirely idle. Methods of prevention and treatment, dependent upon the preparation of special substances from the bacillus itself, have often proved useful, even on a large scale. But before diseases of this type can be put an end to, we shall have to have in India something like the system of primary sanitation which we have here. That time is still incalculably distant, but meanwhile our knowledge regarding the flea and the rat can be applied in some degree, and the spread of epidemics can thus, at any rate, be checked.

But we have not yet done with biting insects, nor with the animal parasites they convey. Once widely spread over the temperate and tropic zones was a disease called relapsing fever, now confined to districts where there is much overcrowding and dirt. It has long been known to be due to a *spirillum*, or "small spiral," a kind of animal parasite not unlike the "spirochæte" of syphilis. In the United States some observers had shown that Texas cattle-fever, or "red-water fever," is propagated by the bites of ticks. In 1904, two sets of investigators proved, in Africa, that relapsing fever is distributed by the bite of a special tick, and now we call the disease tick-fever. Drs. Sutton and Todd went on to show that the spirillum can pass from the infected tick to its eggs, so that the larval ticks which hatch from them become infected, and a kind of epidemic is produced among the ticks, which can subsequently infect man. Pasteur, many years before, had shown that the same thing happens with the parasite of silkworm disease; the infected moth transmits it to her eggs, and so the disease proceeds. It was while working out the same facts in respect of the parasite of relapsing fever that Dr. Sutton became infected with the parasite, and died of the disease.



THE TSETSE FLY, GLOSSINA PALPALIS, THAT CARRIES THE TRYPANOSOMES OF SLEEPING SICKNESS

Having got so far with fleas and ticks, we begin to guess that there is more to find yet. What about cockroaches, beetles, lice, and so forth? May not diphtheria, scarlet fever, typhoid, and typhus, and many more similarly be conveyed by insects? Must we not suspect vermin of all sorts, not merely because they are nasty, but because they may be deadly? In 1909 a few kind and intelligent people enabled a distinguished investigator, Dr. Louis Sambon, to go to Italy and study the disease pellagra, long supposed to be due to the eating of infected maize. He found that this disease is conveyed by a form of small fly, called Simulium. Thanks to Mr. H. S. Wellcome, Dr. Sambon has continued his researches, in Venice and elsewhere; and in the "Times" of September 6, 1912, it was reported that his previous observations had been extended and confirmed. The end of pellagra is at hand.

The domestic fly, Musca domestica, does not bite. We have always had it with us

and we regard it as a necessary nuisance. But after what we have learnt about mosquitoes, and tsetse-flies, and fleas we require to study the fly more closely. It is now known that the fly conveys disease. That amazing genius Dr. Beauperthuy guessed the truth nearly two generations ago. Dr. Howard, of Washington, has lately called the ordinary domestic house-fly the "typhoid fly," and the only objection to the name is that the fly conveys too many other diseases for it to be adequate. "As the water-barrel is to the larvæ of the stegomyia, and the earth-pool to the larvæ of the anophelines, so is putrid, fermenting material to the larvæ or maggots of the fly." The facts are now far too well known to be laughed at. Anyone who realises *in what* the feet of the fly have just been that are now upon his sugar-bowl or in his milk, is more likely to leave the room at once, and urgently, than to laugh. Anyone who, under a lens, has seen the fly vomiting into his food the nameless contents of its stomach will scarcely trouble to inquire whether those contents actually include "pathogenic bacilli."

Here we transcribe the excellent directions now in official use in New York. They are worthy of imitation everywhere, and furnish some appropriate comments on certain practices of our own at which the next

JAPANESE DOCTORS SEARCHING FOR TRACES OF BUBONIC PLAGUE AMONG RATS

generation will marvel, wondering whether we really called ourselves civilised.

Where the fly is, filth is not far behind—in the dustbin, or the stable-yard, or the manure in the garden soil round the house.

The fly does not act as an "intermediate host" for animal parasites, but conveys the humbler and simpler vegetable bacilli, which need no such convenience for their life-cycle. It has been experimentally proved to convey cholera and typhoid and tuberculosis, to which "summer diarrhœa" and the cruel ophthalmia of Egypt must be added. As the anopheline and the stegomyia must go, and have gone from the Panama Canal zone, so the common house-fly must leave our towns. The Corporation of the city of Liverpool was the first to move in this respect, as early as 1906.

Keep the flies away from the sick, especially those ill with contagious diseases. Kill every fly that strays into the sick-room. His body is covered with disease germs.

Do not allow decaying material of any sort to accumulate on or near your premises.

All refuse which tends in any way to fermentation, such as bedding, straw, paper waste, and vegetable matter, should be disposed of or covered with lime or kerosene oil.

Screen all food.

Keep all receptacles for garbage carefully covered, and the cans cleaned or sprinkled with oil or lime.

Keep all stable manure in vault or pit screened, or sprinkled with lime, oil, or other cheap preparation.

Cover food after a meal; burn or bury all table refuse.

Screen all food exposed for sale.

Screen all windows and doors, especially the kitchen and dining-room.

Don't forget, if you see flies, their breeding-place is in near-by filth. It may be behind the door, under the table, or in the cuspidor.

If there is no dirt and filth there will be no flies.

If there is a nuisance in the neighbourhood, write at once to the Health Department.

So much, at present, for the question of man versus insects, though we may be forced to return to it. Even now investigations are proceeding which will greatly extend our knowledge, and make this subject appear more important than ever. But one or two other diseases must be mentioned here, because they likewise depend upon a struggle, now on one side a conscious struggle, between man, with his intelligence, and low forms of animal or vegetable life. The ankylostoma, or "miner's worm," causing the disease known as ankylostomiasis, and characterised by such bloodlessness that the workman cannot work, is one of these. It is widely distributed throughout the world. In the tropics the disease is called Tropical Anæmia. When it broke out during the construction of the St. Gothard Tunnel it was called Tunnel Anæmia; when it breaks out in the mines of Westphalia or Cornwall, it is called Miners' Anæmia; when in Egypt, "Egyptian Anæmia," and so on.

A PART OF A FLY'S FOOT SHOWING BACTERIA ADHERING TO IT

Here the disease is simply contracted by means of infected water and food, where sanitary conditions conduce to such infection. The worm may also pierce the skin of bare feet, and so induce the disease. Once the microscope had ascertained the facts, this mysterious anæmia, against which iron was impotent, could be controlled. In Egypt, the West Indies, British Guiana, the disease is being driven back by the victorious mind of man, like yellow fever and malaria. In Porto Rico and the Philippines, the Americans have done the best work of all; and in our own country the work of Professor Haldane, a member of the family to which we owe the late Sir John Burdon-Sanderson and the present Lord Chancellor, has been effective in controlling and suppressing ankylostomiasis in Cornwall.

For an unknown period of time man has been cursed with the disease called Malta fever, or Mediterranean fever, which infests the islands and shores of the Mediterranean, and is also found in India, China, North and South America, the West Indies, South Africa, and other parts of the world. Now, many years ago, Sir David Bruce, whose work on sleeping sickness we have already discussed, discovered the parasite of the disease, a very small, round bacterium, which is known as the *micrococcus melitensis* – the small Maltese coccus. But for many years this discovery remained unfruitful. The mode of infection could not be traced, and the conventional "art of medicine" could do nothing or next to nothing for the patients. A distinguished personal friend of the present writer, an elderly man, lately contracted the disease in Malta, and recovered only after some years of severe, crippling, and painful illness, despite the best efforts of leading doctors in this country. The patient, who thinks little of science, had neglected to avail himself of the facts discovered by Bruce in 1905.

In that year 403 officers and men were invalided home from our garrison in Malta, owing to this fever, after an average stay of ninety days in hospital there. Well knowing the distribution of the tubercle bacillus in the cow, Bruce returned to the disease which he had studied many years before, and looked for his micrococcus in the goats which yield the milk consumed in Malta. He found that half the goats of the island though healthy, contained the parasite

and in 10 per cent. of them the milk contain the micrococcus. Here, then, were "healthy reservoirs" of the parasite, like the healthy human reservoirs of malaria, whose importance we have already observed. The final proof was obtained through a tragic experiment. A ship sailing to America shipped sixty-five goats from Malta, and their milk was consumed by the captain and many of the crew. All who partook of it, and none others, contracted the disease.

In June, 1906, the campaign against the disease began. The goats' milk was banished from the hospitals and regiments. In the third quarter of 1905 there were 258 cases; of 1906, only 26. For some time the native and civilian population could not be persuaded to follow the advice of science, preferring, like the writer's friend, to adopt the immortal maxim of a noble Viscount and Field-Marshal, still alive, that "medical advice is a very good thing -when it is asked for." But the soldiers and sailors had to obey orders, and the disease vanished from among them. In the Naval Hospital in Malta, practically every patient suffered from the disease, but after stopping the supply of goats' milk there were no more cases. The infected goats were actually banished from Gibraltar, and the disease made its final departure with them. Here ends the story of Malta fever.


MICROCOCCI OF MALTESE FEVER

No disease known to man has a more sinister fame than leprosy. Literature has acquainted us with it—many Biblical passages, and R. L. Stevenson's tribute to Father Damien, who contracted the disease while working for those "butt-ends of men" the lepers among whom he died. Many years have passed since Dr. Hansen, of Copenhagen discovered the "lepra bacillus," which is believed to cause the disease. Hitherto, no progress has been made, following upon that initial discovery. Sir Jonathan Hutchinson, F.R.S., has maintained for half a century, and has often discussed with the present writer, the theory that leprosy is associated with the consumption of decomposing fish, but that view appears yearly less probable. From time immemorial the disease has been looked upon as contagious, yet much evidence exists against this view. What seems possible is that some insect yet again an insect— may convey the disease from one person to another. Dr. Beauperthuy suspected certain insect vermin and also the house-fly. The facts may soon be made clear; and meanwhile the suggested parallel between this ancient scourge of mankind and many another is worthy of note. For in this disease also we have to recognise a struggle between two forms of life, the highest and one of the lowest we know; and it is quite possible that a third form of life may also play an essential part, and so add to the reasons why man must henceforth range his species as a whole against all insects whatever that prey upon his person, his products, his food, or any of his personal belongings.

The dread malady called Asiatic Cholera was proved by Koch to be due to a microbe, of curved form, called the comma bacillus. The same measures which prevail against other bacillary diseases prevail in this case also. Probably no third species is involved in the case of this disease, with the exception of the fly, as a purely mechanical carrier. Our grasp of this disease in its relation to the evolution of man is weakened by its remoteness. We need only turn our eyes to our own cities, towards the end of the summer, and there we find a deadly disease, killing our infants like flies, which is often known as British Cholera, or "cholera infantum." Many years of search have left us still uncertain as to the parasite of this disease; as in the case of yellow fever, small-pox, scarlet fever, etc., we cannot definitely point to any living form, and say that causes the disease. But, at any rate, in the case of yellow fever, our ignorance seems to matter little practically, though science deplores it, for we have identified another link in the chain of causation, and can snap that. We kill the stegomyia, and yellow fever vanishes. So here, though we are not possessed of the crucial evidence which the devoted Americans acquired in Havana, we can say with practical certainty that the house-fly plays a not dissimilar part to the stegomyia, only that the unknown parasite of cholera infantum is apparently simpler than the unknown parasite of yellow fever, and requires no "intermediate host" for the development of its life-cycle. Thus, the fly is not *essential* as the mosquito is essential, but its importance is great, and its abolition would probably save some scores of thousands of infants in this country every year. Such in outline, are the vital relations between the lives of insects and the life of man, so far as science has unravelled them.

MAN AS THE FRUIT TREE'S BEST ALLY

PROTECTING FRUIT-TREES FROM THEIR INSECT FOES BY MEANS OF A GREASE-BAND

ENEMIES OF FRUIT CROPS

Attacks upon the Apple, Pear, Plum, Cherry, Damson, Peach, Hop, Strawberry, and Raspberry

MOST APPROVED METHODS OF DEFENCE

No account of the diseases of plants would be at all satisfactory which did not take notice of the various kinds of pests that from time to time infest our orchards, and attack our various kinds of fruits, even though such an account be limited to a few typical examples of a very large number of similar diseases. It is no uncommon thing to find the crop of a certain kind of fruit almost entirely ruined as the result of the attack of some fungus, or insect, or grub, the result being great financial loss, and much trouble in eradicating the infection. On a smaller scale it is still more common to find a certain number of the apples or pears, or plums, as the case may be, affected with disease that causes their deterioration. We may now, therefore, very briefly summarise the principal points in connection with some types of these diseases, at the same time indicating how they may best be prevented.

Apple-tree mildew is a very prevalent disease in apple orchards, being found almost in every locality during the spring. This means, of course, that the fungus producing it has been lying dormant during the winter months, probably in the form of spores, or possibly by the survival of the mycelium itself. The apple-tree affected has all its leaves at the end of a branch, instead of occurring, as they normally should do, at intervals along the whole growth. Even the leaves that are left are by no means thoroughly well formed, but present a dwarfed appearance, and are covered with a whitish growth of fungus, like a powder. It is especially upon the older, fully grown trees that this mildew is found. Its effect is to check entirely the growth of the branch; and it is for that reason that the leaves along the course of the branch do not grow.

The best treatment consists in cutting off the branch at such a point as will include all the infected leaves on which there is fungus, and the part thus cut off should be burned. It will be found that the branch will subsequently throw out healthy shoots. If it be the case that the leaves only are attacked here and there on the tree, which may happen when the leaves are quite young, a spray already alluded to, consisting of one ounce of liver of sulphur in two gallons of water, may be used, but this proceeding is quite futile if the disease is well advanced. As a precautionary measure the spray may be used upon all the early leaf-buds before they open. Possibly it is a coincidence that the apple-tree mildew is most common on such trees as are also infected with the "green-fly" and the "woolly aphis." Perhaps the conditions favouring all three are identical, but it may be that the two insect pests mentioned may carry the mildew fungus on to the tree with them.

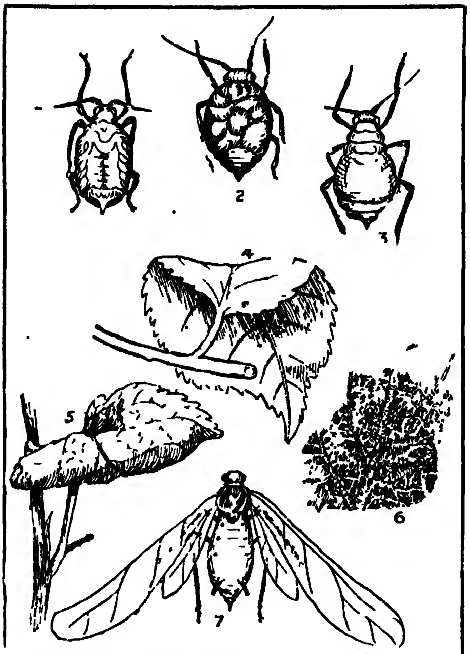
One of the most destructive pests to which the apple is susceptible is the codling moth. It occurs in almost all countries—in Europe, America, and Australasia. To such an extent is its damage realised in Tasmania that the Tasmanian Government introduced legislation with a view to keeping down its ravages. The moth itself (see page 3568) is a small one; and the caterpillars eat their way into the core of the fruit, either causing it to drop off the tree before it is thoroughly ripe, as early as June in this country, or else inducing decay of the fruit after it has been picked.

If a transverse section be made of an infected apple, it will be found that there is a small passage or tunnel leading from a dark spot on the surface of the apple towards the centre. This is the passage through which the caterpillar has bored its way out; and the invader itself may often be found in the core of the fruit, where it has

been feeding upon the seeds. But whether the caterpillar is still present or not, its track remains, though it may have escaped by retracing it steps.

The codling moth by no means restricts its ravages to codlings, for many of the varieties with deep eyes, such as the Blenheim Orange, Cox's Orange Pippin, the King Pippin, the Russet, the Nonpareil, as well as some pears, are similarly attacked. The earlier the variety of the apple, the more noticeable, of course, is the drop of the fruit, and hence, perhaps, this moth got its name of the codling moth. Unfortunately, the fruit-grower is not always aware of the cause of the trouble, and may attribute the condition of things to an unusually dry season, or to some other agent. The serious result of such ignorance is that the apples are left to lie upon the ground, and the caterpillars in due time escape from them, pass into the pupa stage, and ultimately produce moths, and so add to the number of the pests. The same thing happens if the diseased fruit is stored.

Our illustrations show the moth, the caterpillar, the pupa, and the diseased apple. The moth itself is about one-third of an inch long, and nearly three-fourths of an inch from tip to tip of the wings. The hind wings are darker than the anterior ones, and have a golden tint. The moth lays a flat, oval egg, the size of the head of a small pin. The caterpillar is grey, with a black, polished head, becoming brown as it gets older, the body being nearly three-fourths of an inch in length, and pink in colour. The pupa is brown, with several spines.

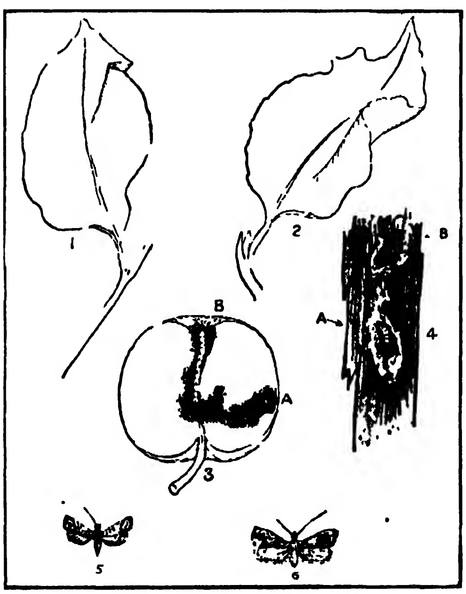


APPLE APHIS, OR GREEN-FLY

, pupa; 2. wingless female, foundress; 3, wingless fe... le foliage leaf bent over owing to ...incturing of its under surface by the young green-fly ...ple foliage leaf sheltering green-fly; 6, part of under-s... of foliage-leaf, showing green-fly; 7, winged female ..., 3, and 7 are highly magnified

Towards the end of May the insignificant little moths may be seen fluttering about in the evening, when the females are occupied in depositing an egg upon the young apple. Each female produces some fifty eggs, and each egg hatches out into a caterpillar, at some time from seven days onwards, working its way in at the eye of the apple, as a rule, towards the middle, where it is in search, evidently, of the seeds. Its track is marked by dark débris.

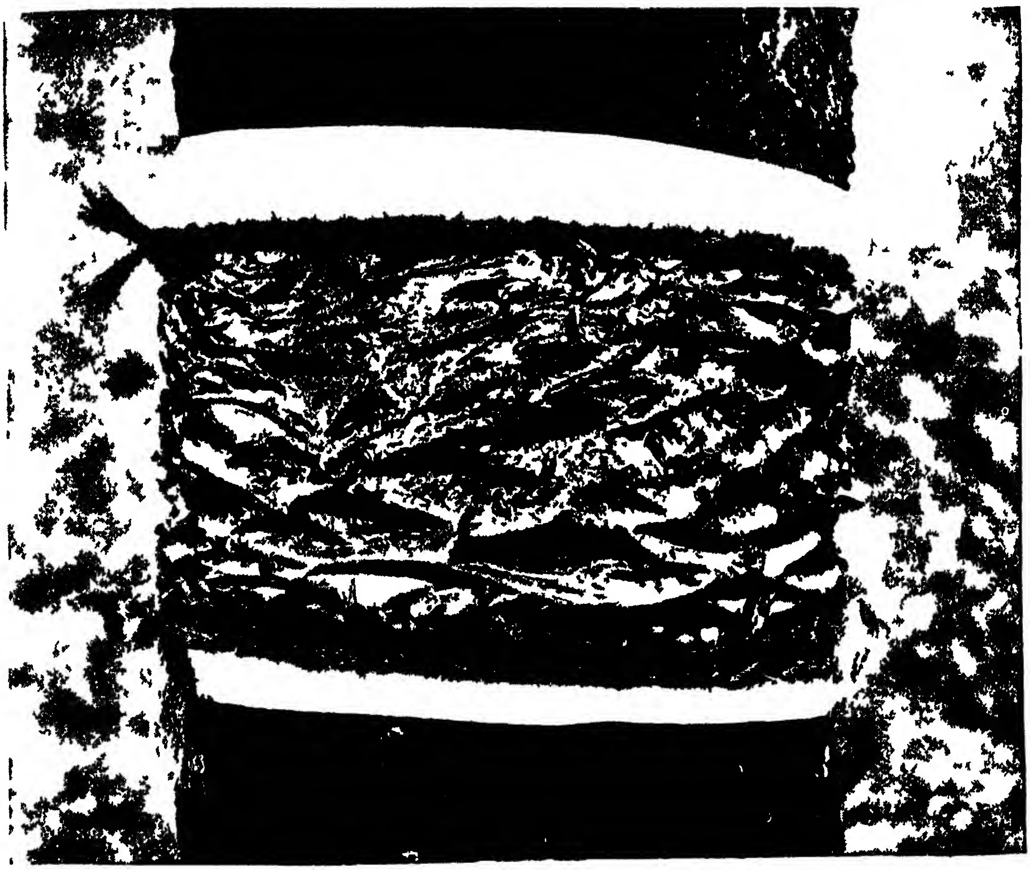
During the growth of th caterpillar in the core of the apple, it quite destroys that part of the fruit, and then makes its exit through another tunn . which it bores in any direction to the exterior. By this time the apple has quite frequently dropped to the ground as the result of the infection, and, if that be the case, the caterpillar simply conceals itself amongst rubbish; but if the fruit be still on the tree it must, on emerging from the apple, find its way to the ground along the branches, unless, as sometimes happens, it lowers itself by means of a silken thread. Many, however, remain upon the apple-trees during the winter, hiding in apertures in the bark, and, as may often be observed, covering themselves over with a silky mass that has a gummy exterior.



THE CODLIN MOTH

1, pear leaf; 2, apple leaf; 3, apple cut open, showing (A) puncture in rind made by caterpillar for ejection of debris, and (B) position of egg in blossom or young fruit from which caterpillar emerged; 4, piece of bark containing (A) caterpillar, and (B) chrysalis; 5, male, and 6, female butterfly.

A knowledge of the life history of this and similar fruit-pests is the only basis for scientific treatment or prevention, and from what has already been said it must be obvious that the bark of apple trees should not be left to become rough and corrugated, and so afford hiding places wherein the caterpillars may congregate. It should therefore be frequently scraped so as to remove all excrescences. A method of catching the ascending or descending caterpillar is that known as "banding" the stem, practised largely in the Colonies, and enforced by law in Tasmania. This consists in tying round the stem, close to the ground, some form of band, either of hay made into a rope, or some other material, in the folds of which the caterpillars climbing either up or down are entangled. The band must be examined from time to time, and the entangled caterpillars carefully destroyed.



THE GREASE-BAND ROUND AN APPLE TREE, WITH CAPTURED WINTER MOTH

Careful attention should be given to the falling and fallen apples, which should not be allowed to lie unnoticed upon the ground. A good plan is to allow the poultry, or pigs or sheep to have access to the orchard, for one or other of these will consume both apples and caterpillars. All buildings used for storing the apple crop should have their floors thoroughly well cleaned and their walls whitewashed.

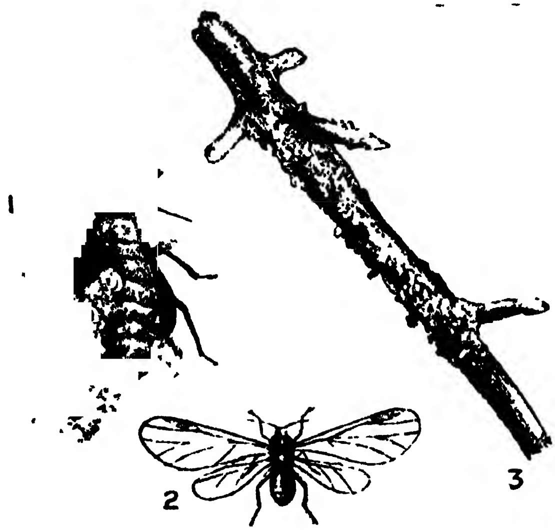
This is one of the instances in which the fruit grower does well to encourage the presence of birds, because these insect pests are eagerly devoured by the members of the Tit family, as well as by poultry. Spraying the trees with Paris green immediately after the fall of the blossom is advisable, because at that time and then only is the eye of the apple sufficiently open to allow the poison in the spray to act thoroughly. Lastly, it should be remembered by dealers in apples that all cases and barrels that are imported into this country may be possibly infected, and they should accordingly be destroyed by burning.

In the woolly aphis or apple root louse, we have to deal with an insect which is, unfortunately, all too common in apple orchards of considerable age. Occasionally, too, it is found present on young trees and sometimes even on those that are sent

out from nurseries, in which case it does its worst damage. It is probably by this means that its distribution is most widely effected. Originally the disease was a European one, but the modern dissemination of young apple-trees to all parts of the world has also dissseminated the woolly aphis from country to country. It is now a universal infection, known across the Atlantic as the American Blight.

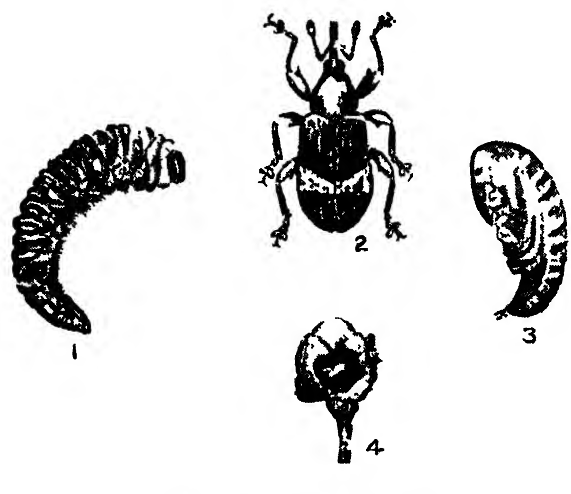
No variety of apple is immune to its attack, but amongst the most susceptible must be mentioned the Ribston Pippin, the Blenheim Orange, Cox's Orange Pippin, and Lord Suffield. One of the most interesting points in connection with this insect is that it can live under the ground, on the roots, hence one of its names; but it also attacks the trunk, branches, and even the leaves in bad cases. This is a very important point to be noted, because it means that it is not sufficient to eradicate the pest from branches and stem, but treatment must involve also the root itself.

The damage done by the woolly aphis, as in all the members of this group of insects, is effected by means of puncturing the external tissues of the tree, and extracting the sap through the proboscis of the insect. This naturally deprives the tree of its nourishment, and, not only so, but causes cracks to appear on the outside. In these cracks may be seen a whitish, woolly appearance, which indicates the presence of the aphis. It is an excretion from the female (see below), and sometimes contains the young, and can therefore transfer the infection from place to place if blown about. The females are reddish-yellow in colour, extremely minute, each laying one egg in a crevice on the bark of a tree, usually near the base. The egg hatches out during the next spring.



THE WOOLLY APHIS, OR APPLE-ROOT LOUSE
wingless viviparous female; 2, winged female; 3, apple twig covered by woolly aphides

Once more we are dealing with a very serious fruit disease in which the greatest assistance to man is given by the Tits, especially the Blue Tits, which devour enormous numbers of this insect pest, and many others, at all times of the year. There is no more valuable assistant to the fruit-grower than the Tits, and every opportunity should be given to them to visit orchards, where they should always be regarded as most welcome visitors.



THE APPLE-BLOSSOM WEEVIL
1, larva: 2, weevil; 3, pupa—all magnified 4, larva in blossom-bud.

All apple trunks that are covered with moss, and have coarse grass around the base, harbour this pest. Different solutions have been advocated to deal with it. A recent one, highly recommended, is made as follows.

"Dissolve one and a half pounds of soft-soap in one gallon of water by heating it; add to this gradually two gallons of paraffin, churning up the whole with a syringe fitted with a rose-jet,

until it becomes a thick, creamy emulsion; stir this emulsion into twenty-seven gallons of water in which six pounds of caustic soda have been previously dissolved."

In using this wash, the face, hands, and clothes of the workmen must be protected. The wash has been devised and advocated as the result of experiments by Mr. Spencer Pickering, of Woburn. Whitewashing the stems of apple-trees is another old-established method of protecting them from the attacks of these insects, but it is quite useless unless all the rough bark has been scraped off first. The best whitewash for this purpose is one made of soft-soap and lime in the proportions of one pound of soft-soap, one gallon of lime, a little size, with enough warm water added to make a thick wash. Whatever method of treatment be adopted, it should be remembered that the wash should be applied directly the woolly appearance is seen upon the bark. As regards the infection in the neighbourhood of the roots, prevention must be the rule here, and this can only be done by most careful inspection of the young trees before they are planted. If, however, damage is obviously being done at the roots, bisulphide of carbon should be forced into the soil about a couple of feet away from the trunk in several places. It must not come in actual contact with the root; the idea is to allow the vapour from it to filter through the interstices of the soil, remembering always that this is a poisonous and inflammable substance.

Great attention has been paid to this infection in Australia and New Zealand; and experiments seem to show that two apples, namely, the American Northern Spy and the English Norfolk Majetin, produce immune stocks. It is said that by using blight-proof stocks the fruit-grower may snap his fingers at any danger from American blight. Curiously enough, these two stocks are but very little known to apple-growers in this country.

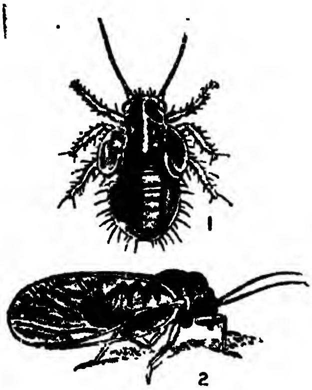
AMERICAN BLIGHT ON AN APPLE-TREE TWIG

The apple-blossom weevil, only too well known in the apple and pear growing districts of France, has of late years increased its ravages in our own country. The cream-coloured larvæ of the weevil are found in the middle of the flowers of the blossom, where they destroy the fertilising structures. The weevil is only a quarter of an inch long, blackish in colour, with a V-shaped mark when the wings are closed, and, like many other insects of the same group, folds itself up as if dead when touched. Issuing early in the spring from their winter quarters, the female arrives at the apple-blossoms, and bores a hole with her proboscis in each bud, and in this she inserts one egg. The process takes her about an hour, and she proceeds to deposit in this manner anything up to fifty eggs. About a week later the larva, which hatches out, can be found lying curved up in the bud, and when the blossom opens its decayed character is quite evident.

As treatment, the branches of the trees may be sprayed early in the year with caustic alkali wash, or a dilute spray of kerosene emulsion. It is recommended that the branches be shaken, so that the insects fall out on to some cloth spread out underneath the tree to catch them. The cloth must then be quickly swept with a brush before the insects escape, and the contents be destroyed. It will be necessary to repeat the process for each tree several times. An orchard of some eight acres has yielded

450,000 weevils from 347 trees by this method of treatment, and a good crop of apples resulted. It is perhaps as good a way of prevention as can be devised.

The apple-sucker is also an insect which conceals its larvæ in the buds. It attacks the leaf-buds, the leaves in foliage, but, worst of all, the blossoms which fail to expand, and so the crop of fruit does not mature. The perfect insect, seen from May onwards, is yellowish-green in colour, as a rule, but varies at different periods. It can often be seen in great numbers, looking rather like flies, on the apple-leaves in autumn. It may be recognised by its mode of progression —a jump before expanding the wings.



APPLE-SUCKER
1; 2, perfect insect.

The eggs are laid about September, and placed upon the shoots of the tree in cracks. The larvæ emerge in the spring. It follows, therefore, that attempts to deal with this pest may be carried out either in the autumn or the spring Infested trees may be sprayed with paraffin emulsion, which is composed as follows: paraffin, two gallons; water, one gallon; soft-soap, half a pound. The soap and water are boiled and poured into the paraffin, and the whole is mixed into a creamy consistence, and diluted with ten gallons of water. Or the caustic alkali spray may be used, but this is probably not so good.

APPLE SCAB

PEAR SCAB

In this, as in other cases of apple-tree parasitic infections, all dead leaves should be carefully gathered together and burned. In fact, the careful and regular destruction of the rubbish from fruit-trees, and under them, should be a routine proceeding, and would save much trouble.

Apple and pear scab is caused by a fungus, each fruit having its own species of fungus which attacks it, but the two species produce a very similar appearance. No fungoid disease in these two fruits is so common as this. The ordinary observer only notices the result on the fully grown fruit, on which are seen a number of black scabs, or spots, with cracks on the surface. These, of course, spoil the appearance of the fruit and therefore interfere with its highest prices, though they do not penetrate into the interior.

To combat the condition it is necessary to attack the fungus when it is still on the leaf, or when the fruit is very young, and this may be done by spraying with the usual Bordeaux mixture of *half the ordinary strength* the full strength being too strong for the delicate foliage In a badly infected orchard it is advisable to use a good winter wash in order to penetrate the interstices of the bark, in which the spores of the fungus will be passing the winter.

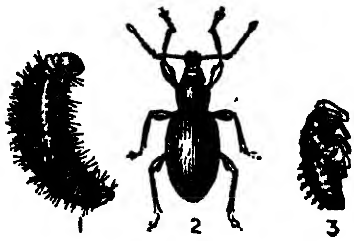
THE SAWS OF A SAW-FLY

Pear and cherry saw-fly is a well-known and ugly looking larva often termed "slug worm" or "sneg." It attacks not only the apple, the pear, and the cherry, but also plum damson, and peach trees The fly itself does not do any direct damage, but is the depositor of the eggs which ultimately produce the larva whose ravages on the leaves are disastrous. Ultimately every portion of the green foliage may disappear in a bad case.

Once more let us draw attention to the general principle in physiology her

illustrated—namely, that in order to produce perfect fruits the green foliage must be intact. Any interference with it damages nutrition.

The larva is at first white, then green, becoming slimy and almost black. It is thicker at the head end, and tapers towards the tail, looking rather like a badly developed slug, and having a very repulsive aspect. When fully grown, it is about half an inch long. Finally, after several moultings, it is of a yellow colour. The fly, known as the saw-fly, pierces the leaf with her saw, and deposits an egg in the crack thus made. A number of eggs may be found frequently upon a single leaf, or rather under a leaf, for it is on the under surface that the egg is deposited. From this egg the larva makes its appearance on the upper surface of the leaf, the whole of which it begins to devour with eagerness. Finally, it reaches the ground, where it passes the pupa stage, becoming then a larva.



THE BLACK OR VINE WEEVIL
1, larva; 2, weevil; 3, pupa—all magnified


CATERPILLARS OF THE LACKEY MOTH

Inasmuch as the pupæ are in the earth underneath trees which have been infested with the larvæ, the attention should obviously be directed to this spot in any efforts to get rid of the pest. Quicklime may be placed on the ground, or the soil dug up round the trees. Poultry will remove a certain number, or the leaves may be treated with a wash made of one pound of Paris green in 200 gallons of water. Other poisonous washes may also be used when the trees to be treated are the apple, plum, pear, or damson. In the case of the cherry, the fruit is nearly ripe, as a rule, when the attack of the larva takes place. The worst damage is always done in hot, dry seasons.

The vine, plum, hop, and raspberry are all subject to the attacks of weevils. The weevils in this group are the black weevil of the vine, the clay-coloured weevil of the raspberry, the red-legged weevil of the plum, and the ivy and hop weevil. In the case of the hops, the leading shoots are much damaged by the larvæ which have been feeding upon them, and consequently the plants droop. Similarly, the vine weevil penetrates the young shoots of the vine plants, and the weevil of the raspberry in like manner attacks the young growth of that plant.

The red-legged weevil of the plum is the enemy not only of this fruit but of the raspberry, strawberry, peach, nectarine, and apricot, especially in southern England. In the beetle stage the leaves and buds are destroyed, while the larvæ attack the roots of the strawberry in the winter. All these weevils evidently feed upon many kinds of plants, because they are found in connection with almost all the farm crops. In the case of plants trained to an upright support, as the hop or the raspberry, the pest may be captured and destroyed at night, by shaking the support on to a tarred board on the ground. If the land be badly affected, autumn treatment of the soil, by one of the methods mentioned before, must be carried out.


SLUGWORMS UPON A LEAF

REAPING ONE OF THE MANY ABOUNDING HARVESTS OF THE STORMY BRITISH SEAS

A SCENE DURING THE COMPLETION OF A SUCCESSFUL HAUL OF PILCHARDS OFF THE COAST OF CORNWALL. FROM THE PAINTING BY C. NAPIER HEMY

OUR BREAD ON THE WATERS

Strange Life-Stories of Sea-Fish Which Come to Our Tables

ILLIMITABLE RESERVES OF FOOD FOR MAN

THE naturalist has followed the fisherman to sea, and is teaching, guiding, and controlling him. The fisherman's policy is to take all out that he can, recking not of tomorrow. The naturalist teaches him the importance of conservation of natural resources, stays his hand in its grasp of immature fish, instructs him in the art of increasing the store upon which he has to draw. The natural bent of the fisherman is to retain all that comes to his net, and to dispose of that which cannot go to the food market as manure for the farmer's land, or offal to the sea. He scorns, if left to his own devices, the fact that the cargoes of immature fish he thus throws away might, if permitted to mature in their natural habitat, suffice to repopulate the seas, to his own immense advantage.

We have over 35,000 men regularly engaged in our English and Welsh fisheries, with another 8000 occasionally employed, and a vast number indirectly concerned. These men bring to port, in the course of a year, fish representing about $11\frac{1}{4}$ millions sterling, and, in point of weight, over a million tons. Painstaking naturalists have gone out to the fishing-grounds and sought by careful tests to estimate the number of fish spawning in the North Sea. Henselt and Appstein have presented figures as to the more familiar denizens of the deep which suggest a good deal of thought. During the time of their investigations, the spring of 1905, these numbers, in millions of fish, were, they estimated, as follows: Cod, 44; haddock, 180; plaice, 103; flounders, 38; dab, 840—a total of 1200 million of mature female fish. To this must be added 430 millions, the estimated number of mature male fish, plus the total immature fish of both sexes, 8180 millions. The grand total of the fish in question would thus be, in this one area, an unimaginable 9800 millions.

It is probable that these figures underestimate the actual totals. When we reflect that in three months during the season of 1911 no fewer than 854 millions herrings were landed at Yarmouth and Lowestoft, a number greatly in excess of all records for any entire preceding herring season, we see that no calculation could have provided for such figures. Mackerel, too, probably exceed by far any sort of estimate that we are likely to have to consider. One particular fleet, five years ago, ran into a "sea" of mackerel fifty miles in circumference, and other fleets missed it. Now, mackerel in their shoals pack so tightly that they have been seen almost to suffocate a grampus which dashed into their midst. Who could number with accuracy this unthinkable host, fifty miles in circumference? And this was only an isolated group, the massing together of the progeny of a certain number of fish, all approximately of the same age and size, and unable, therefore, to destroy one another. The seas are not inexhaustible, but it is unlikely that we know as yet anything like the actual number of their inhabitants, which vary so much between a favourable and a bad season for hatching as to defy the summing of the observer.

The ordinary fisherman is not the source of information upon which we can rely. He has still to be taught his business, not as to how he shall shoot his nets or land and cure his catch, but, as we have said, how he shall make that which is already mighty in number still mightier, by nursing the children of the seas as we nurse the product of the garden, the orchard, the vineyard, and the field. Little by little we are extending our knowledge of the conditions and possibilities of sea-fish life, and have reached the conclusion that man may improve upon the methods of Nature in the waters as he may upon the land. He transports

fish from one sea to another, restocks depleted waters, creates new sea populations But, although it is striking enough that eggs should be taken, packed in ice, from one side of the world to be hatched on the other, and that here, there, and in every civilised land man should be constituting himself the foster parent, as it were, of various fishes' young hopefuls, there seems something even more challenging in the latest scheme—the putting of little fish out to nurse It has been done so far in only a small way, but the result is very significant Small plaice have been caught in shallow inshore waters and carried out to the richer feeding-grounds of the Dogger Bank Tests made by the Marine Biological Association with marked fish show the following returns

From an average length of 8¼ inches, transplanted fish grew in one year to 14 inches whereas those not transplanted increased only to 10¾ inches In weight the increase of the transplanted fish was 382 per cent as against 100 per cent for the others We have here a beginning, and only a beginning, just a mere hint from science to those commercially interested in sea fishing, but the possibilities are obviously infinite Some day, when science and the fisherman reach more than a nodding acquaintance, we shall have as sane a system of conservation of sea-fish larvæ, possibly even to some extent of fish eggs, as we have in regard to salmon, trout, oysters, and, by a later development, of lobsters

Heavy as are our supplies of fish, the demand will grow as facilities for its inland transport are improved Experts are unanimous in their advocacy of fish as a beneficial diet, and when transport methods render it possible for the fruit of the seas to reach the crowded country areas in fresh and healthy condition—which is not today possible—the industry of the fisherman will be an increasingly profitable one, attracting enhanced numbers of men, and still more expeditious and wholesale, but more prudent, methods of capturing the fish It will then be absolutely imperative to take steps to safeguard and, if possible, to increase the source of supplies, and the Dogger Bank experiment is of high importance as a pioneer example of what may be achieved by systematised effort upon a wider scale Let us glance at some of the most important families of fish from which our food supplies are drawn

The democratic herring, which is the poor man's salmon, is a member of one of the most important of these families Were they scarce enough to sell for a guinea apiece they would rival salmon in distinguished favour, as it is, they are left severely to the working classes The humour of it is that anatomically they are closely allied to the salmonoids though naturalists are far from unanimous as to including the whole in one family The accepted plan is to brigade the herrings with the sprat the pilchard the anchovy and a couple of shads as the family Clupeidæ The herrings themselves are common to both sides of the northern Atlantic and range eastwards to the seas on the north of Asia They deposit their eggs near shore, where they sink after being fertilised, to hatch out upon rocks and the sea-bottom Innumerable millions are destroyed by fish, by crustaceans, and by nets, but on the whole the plan has as many points in its favour as that of the eggs laid at or near the surface The shads, too, sink their eggs and these might on the whole be thought to have the better chance, for whereas the ova of the herring adhere in clumps ensuring disaster for a whole group when one is attacked, the eggs of the shad develop singly

A HERRING AND WHITEBAIT

The massing of the herrings in the enormous shoals of which we frequently read has provoked considerable speculation No fewer than 320,000 were taken at a singl

haul during October, 1912, by one boat, which left a vast remainder to other craft. One painstaking investigator reached the conclusion that the herrings swarm in myriads the better to protect themselves against rorquals and other large enemies. He pointed out that a large enemy, such as the rorqual, engaged in an attack upon one of these colossal shoals, runs the risk of suffocation or death, much as used to happen to beasts of prey which strayed into the line of march of the multitudinous springboks. And he cited a rorqual which he saw in extremities in such case. Hampered by the enormous mass of its prey on attempting to rise to breathe, the whale had to leap clear of the water to effect its purpose. This he mentions as proof of his theory that there is safety in the numbers of herrings. But a similar phenomenon may be observed wherever herrings swarm. They are followed by flocks of predaceous sea-birds and by schools of whales, feeding with as little danger as birds and beasts of prey feed upon a migrating host of lemmings. The whales do have to leap into the air at times to breathe, but that is their business, not an accident. The best explanation seems to be that herrings, hatched at about the same time over a wide but connected area, assemble, as birds and as mammals of many kinds assemble, because each and all are inspired by one idea--the search for food, that is to be gained in a certain direction towards which instinct guides them.

THE JOHN DORY

Needless to say, the "hard roe" of the herring comprises the eggs of the female, while the soft-roed herring is the male. Certain other table fish, such as the pilchards, spawn considerably farther at sea, hence we do not get roes with these, their spawning-grounds lying beyond the range of the fishing-boats.

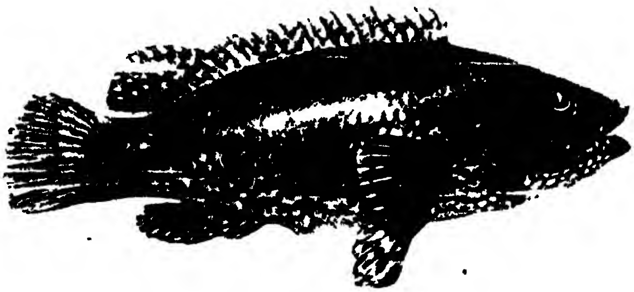
Herrings are an ancient generalised type, connected by extinct species with the ganoid fishes, of which the sturgeon is today the famous example. They are sea-fish in the main, but can take to the brackish waters of tidal rivers, and Australia has true fresh-water herrings, which are survivors of a stock that once haunted the waters of both the Old World and the New. Male herrings are believed to be slightly in excess of the females, which is unusual in fish life, as in other phases of the scheme of creation. One male is capable of rendering fertile the eggs of several females, and investigations show that females largely preponderate as a rule, to which, however, the herring is not the only exception.

Whitebait, which have lured so many statesmen to annual dinners at Greenwich, statesmen who would have swooned at the thought of eating herring, are simply the young of the latter fish and of sprats, together with a few surprising others. All are whitebait once they have reached the net. The sprat is abundant on the Atlantic coasts of Europe. It is only about half the size of the herring, and deposits some 5000 eggs, close inshore, and even high up estuaries, the less dense water of which, it is suggested, is favourable to the sinking of the ova to the bottom for hatching.

The pilchard, another popular member of the herring tribe, is interesting as a migrant, and famous as a bone of contention in the law courts. It is apt to change station, and not to return to a spot once deserted, as fishermen on the East Coast of Scotland have occasion to remember. Most naturalists agree that the sardine is simply a young pilchard, but a recent legal action, heard at great length, seems to imply that other little people of the deeps have as good a right as junior pilchards to pose as sardines. The same method which allows us to call an elderly shrimp, or a youthful pipefish, whitebait should be elastic enough to include as sardines anything palatable enough to deserve the name.

Both the shads which frequent British waters are larger than the herring. Although

essentially marine fish, they ascend rivers to spawn, though not apparently beyond the limit of brackish water. American fishermen have carried out an interesting experiment with shad, transferring them from their Atlantic seaboard to the Pacific. The cutting of the Panama Canal will have an extraordinary effect upon the fish families of the two seaboards of America, and the shads artificially introduced may



THE BALLAN WRASSE.

prove to have colonised the Pacific only just in time to anticipate voluntary arrivals of their genus from the Atlantic by way of the Canal.

Another group brings us to the bass, the sea-bream, and the mullet. The first-named is a fierce, voracious fish, which when mature measures three feet in length, but is most prized as food when only half that size. The bass reaches the coast in shoals, and often spawns in river-mouths, while three species are restricted to fresh water. The sea-perches are numerous in species, and some ascend tidal rivers. These, however, are only there in quest of food, being normally marine in habit. Very numerous, too, are the sea-breams, and it is worthy of note that of one of the largest, the " sheep's head," the flesh is specially excellent. As a rule, large fish become coarse, but in this instance we have an exception.

We have some forty species of red mullet, characterised by notable variations, but all equipped with two strong and flexible barbels, with which the fish feels for its food in muddy sea-bottoms, folding these barbels back, however, into grooves when swimming. The grey mullets belong to quite another family. They are numerous in species. All can safely be transported from salt water to fresh. Their flesh is palatable, but not to be compared with that of the more costly red mullet, whose vivid colour upon the fishmonger's slab, however, is enhanced by the art of the tradesman, who scrapes away the large outer scales of the fish the better to reveal its hidden hues.

The mackerel introduces us to another series of related groups, of which the mackerel itself is commercially of most importance. The true mackerel is one of the most perfectly adapted of fish. Mackerel have enormous muscular development, and the muscles, to compensate for the almost continuous and violent exertion to which they are submitted, are abnormally charged with blood-vessels. The protective coloration is perfect, and their wide range of food admirable for the maintenance in health and vigour of an enormous number of the genus. They spawn at sea, but during their migrations flee landwards in quest of herrings and their fry, which at such a season constitute their normal diet. Lacking this, they flourish on the inexhaustible minute floating crustaceans with which the sea is crowded. The horse-mackerel, of which only one, popularly called the scad, is a native of British waters, attains great size, but, though edible, it is coarser than the common species, and that is strong to many tastes.

Another esteemed food fish is the John Dory, which curious title is believed to be a corruption of the old Gascon name " jan dorée," meaning gilded cock. It attains in British waters a weight, when full grown, of at least 18 lb. The deep, compressed form of the body, which looks so strange and inelegant in a shop, admirably serves its purpose in securing food. When seen head on, the fish is a mere thin, blurred line. It advances in a curious lopsided fashion upon its unsuspecting prey—small sprats, gobies, sand-eels, and so forth. When near, it suddenly shoots out its telescopic mouth, and makes its grab—so neatly that the companions of the victim are not alarmed, but remain to be captured in turn when the first has been comfortable disposed of.

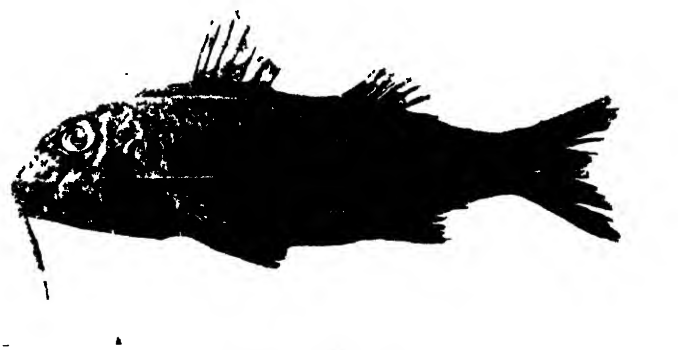
The tunnies, which are included in our present group, comprise some very fine fish, with a length of over ten feet and a weight of half a ton. A near ally, the bonito—a deadly enemy of the flying-fish, which it drives from the water into the air, there to become the prey of some waiting sea-bird—is a smaller fish, rarely more than a

yard in length, but the albicore, with which it is commonly found in company, is twice the size. While on the subject of large pelagic fish, the tarpon may be mentioned. With a length of only six or seven feet, it exceeds one and a half hundredweight.

The man who orders a sole for breakfast may feel disposed to be thankful that the fish has chosen so convenient a shape for the plate, but he little thinks what a freak is before him, and to what a freakish family his delicacy belongs. All the flat-fish are born perfectly symmetrical larvæ, shaped like other fishes. But some ages ago the ancestors of the family took to ground-feeding, starting perhaps from some such shape as that of the John Dory of today. The shape was inconvenient. The fish became tired of the vertical, we may imagine. It was necessary to remain long upon the ooze to secure full measure of food, and the weary fish canted a little to one side to secure greater support than was obtainable by contact merely between its ventral surface and the ground. And today, at a certain stage in the early infancy of the flat-fish, there comes a renewal of that canting over. The body leans towards the left. Back and belly cease to be uppermost and lowermost; the left side becomes to all appearance the ventral side, the right side the back. But that necessitates a change in the character of the head. That, too, must be flat, and flattened it becomes. That leaves the left eye in a difficult position, and that organ, conforming to altered conditions, travels round from the left side of the head to the right side, though in certain species this progress of the eyes is reversed. And whether it be sole or plaice, halibut or turbot, every flat-fish that comes to table has undergone this extraordinary metamorphosis. The fins which we discover along the "sides," as we call them, are really the vestiges of back and belly; the under part of the fish is simply its left side, the upper part its right.

Thus shaped, the flat-fish can feed resting upon the sea-bottom. It desires no more active life. It travels, unless carried by the tide, a mile an hour, and no more. Another point to be noted is as to coloration. The larvæ are coloured on both sides alike. When the change of outline comes about, however, the left side, which becomes the lower, resting upon the muddy bed of the sea, loses its coloration, which is restricted to the right or upper side. This might pass unnoted were it not for the more remarkable fact that the scheme of protective coloration may be seen by experiment in actual operation. A flat-fish which has passed through all the necessary transformations, and fixed the tone of its unpigmented under side, can be caused to revert, as to this under side, to the coloration to which it was hatched. Such a fish, placed in an aquarium, with light reflected from below, gradually adopts a pigmented left side precisely matching the tone of its right side. By what process the change is effected and its need recognised by a creature of such lowly organisation as a flat-fish psychologists must decide.

Nature performs the miracle for the flat-fish; the latter have little enough to do for themselves. They lie for the most part quiescent, buried in mud or sand, with their elevated eyes raised just clear of impediments, enabling them to detect the proximity of potential food. The king of them all, in point of size, is the halibut, which attains a length of seven or more feet, and very great weight. The recording naturalist sets down 320 lb. as a figure to be accepted with reserve. Billingsgate is a better authority, where weights are checked for business purposes. The best halibut on record at the great fish-market was one brought up from Hull in May of 1911, where it had been landed from the White Sea trawler "Macfarlane." Unfortunately, its dimensions were not noted, but its weight was, and that was published as exceeding 700 lb., which is a very respectable bulk for a flat-fish. The expert declares that the flesh of these gigantic halibut proves quite



THE RED MULLET

as palatable and nutritious as that of the smaller examples.

The turbot, an extremely prolific as well as a weighty fish, is declared by the gourmet to be by far the best food-fish of its tribe. It attains a yard in length, and, feeding entirely upon other fish and crustaceans, resembles the angler-fish in its habit of burying itself from the view of its victims. Brill, which also has its following, is a rather smaller fish; but while 30 lb. is set down as a good weight, considerably greater figures have been noted.

The plaice and flounder are alike in that the jaw and teeth are much more developed on the left or lower side than on the other. Plaice find their food-staples among razor-shells—the muscular foot of which is eaten—lugworms, cockles, etc. The plaice keeps well to sea, but the flounder ascends brackish waters, except at spawning time, when it fares forth into deeper water that it may safely deposit the eggs. The sole diets itself chiefly on worms, which it traces by sight, smell, and touch. The latter sense is aided by the presence of delicate tactile filaments on the side of the head. Trebly armed in this manner for the chase, the sole relies less than the others of its tribe upon vision, and eyesight is decidedly not its strong point.

A SPEARED TARPON LEAPING OUT OF THE SEA

The bulk of the flat-fish hug the shore, but some of the larger find safety and an ample food supply 600 feet deep. Whatever their normal station, they with one accord put out to sea when about to spawn. They deposit their ova upon the surface of the sea, and various interesting devices are noted as to the manner in which the eggs are kept afloat, some by their own buoyancy, some by capsules of oil which maintain each egg in a certain position, some again in an oily envelope which merely secures a floating position, no matter what part be uppermost.

This retreat from the shore at spawning time has engaged the attention of more than one biologist, and various attempts at a solution have been made. One suggestion was that the increased pressure of a greater depth of water assisted the female in the extrusion of the eggs. That, however, cannot be substantiated. Of other explanations the most feasible is the simplest, albeit it implies another high tribute to the teaching by Nature of her humble children. The inshore waters are crowded with multitudinous life. Deposited in such surroundings, the ova would, for the most part, be devoured. In the struggle for existence the flat-fish have produced species and genera which have acquired the habit of going out to sea to spawn. The progeny of those which early formed the habit of doing so have survived, and the instinct is born in each generation to weigh anchor and betake themselves to the deeps when the spring is at hand. Cast upon the surface of the sea, the ova mature and hatch before the tides have carried them back to the danger-zone in the vicinity of the coast. The larvæ, when hatched, are very active, and are able at once, if not all to escape their enemies, at least to make so bold a bid for safety that a large percentage live to carry on eventually, in turn, the providential habit of seeking secure nurseries in the open sea.

We turn finally to the cod family, which, in point of classification, though not in interest, should really take precedence of the group last considered. This tribe, though not to be compared with the flat-fish for delicacy of flavour, is really more important economically, for not only does the cod yield a highly valuable medicinal oil, but the flesh both of cod, haddock, ling, and hake takes salt so readily as to constitute a preserved food supply of almost unrivalled importance. Cod, haddock, and herring are brought in their natural state in countless hosts to England; they leave, salted or otherwise cured, to form a food supply for peasant and poor in the remotest

hamlets of Europe. Of the part that the cod played in the development of our oldest colony no one needs to be reminded. Keeping at times to depths as great as 700 feet and more, the cod is a voracious feeder, taking all manner of fishes, young sharks and dogfish among them. It serves, in turn, to stay the appetite of the shark itself, while many a mantle of sealskin has come from animals nurtured upon the cod. Varying in size according to the nature of its food supply, the cod, at its best, can turn the scale at 100 lb. They are caught ordinarily by hook and line, but, as in common with other fish, they rarely feed at spawning time, they are then netted by trawlers.

The haddock is the nearest relative of the cod; and though smaller examples are the more common, some well-favoured specimens come to hand which measure well over three feet in length. Associating in large shoals, these fish approach the coast when about to spawn. In stormy weather they retire to deep water in which seaweed abounds. Here they are doubly protected — against the violence of the waves and against the wiles of the fisherman. The haddock is an off-shore fish, and quite tiny fry are to be found in water 180 feet deep. They realise that danger lurks in shallow water; numbers were found dead following a storm in the insufficient depths of the Humber. The eggs of the haddock may number as many as two million.

A BLACK SEA BASS WEIGHING 320 POUNDS

The most popular member of the cod tribe is undoubtedly the whiting—popular, that is, with the epicure. Its weight varies between 1½ and 4 lb., though, of course, still larger specimens are at times brought to market. This fish preys upon the larvæ of other fish, and, like the rest of carnivorous fishes, is a pronounced cannibal. Although young cod and young whiting are hardly distinguishable by even the expert naturalist, the children of the seas make no mistake. In proof of this we may mention that there is one special parasite for the whiting and another for the cod.

The pout, or rock-whiting, is another common British fish, though not of great account as human food; and the pollack, though more acceptable when fresh, decomposes too rapidly to make it a possible source of revenue to purveyors at a distance from the seaside. It is worth noting as a peculiarity that, whereas some fish cease absolutely to feed on the eve of a thunderstorm, the pollack is said to bite with exceptional avidity at such a time. Cornish fishermen explain this peculiarity on the ground that the pollack is conscious of a coming change in the weather, and desires to feed and to retreat to safe deep water, much as a bee, disturbed in its hive, will gorge itself with honey preparatory to flight.

The hake, one of a genus belonging to an extensive group, is another of the staples of those who can subsist on a salted diet. It is caught in enormous numbers off the coast of Cornwall, whither it pursues the pilchard shoals, but is very capricious in its movements. Its near relative, the ling, a marvel of fecundity, also goes cured to the poor man's table. It grows to a length of seven feet, and one has been known to weigh over a hundredweight.

So far attention has been directed solely to the food-fishes which the seas supply. There remain for notice in a later chapter those which are restricted to fresh water or divide their time between river and sea.

THE CONTAGIOUS PASSION OF THE MOB WHICH GREW TO "THE RED FOOL-FURY OF THE SEINE"

FROM THE PICTURE "TO VERSAILLES" BY VAL PRINSEP ILLUSTRATING THE MARCH OF THE STARVING WOMEN IN THE FRENCH REVOLUTION

PROCESSES OF THE MIND

An Examination of the Operations of Suggestion, Imitation, Habit, and Temperament

THE HOW AND WHY OF OUR BEHAVIOUR

In our study of man we are steadily advancing towards true ideas of the why and the wherefore of his acts. We know, or ought to know, that nothing else really matters. We might therefore have begun our account of him by considering his will, his purposes, his character. If we have done otherwise, beginning with merely physical and physiological considerations, that is only because the history of thought teaches us the advisability of doing so. Many thinkers and students of man in the past have begun with his supreme and essential attributes, but we believe that they have often erred because they were not content to begin with the base degrees by which he did ascend. On the other hand, we may safely prefer their account of man to those provided by too many physiologists of today, who begin with the base degrees, and, being unable to get any further, end by denying that man, as he really is, exists at all.

At the British Association Meeting in 1912, the famous physiologist Dr. J. S. Haldane clearly and profoundly stated the apparently opposed and irreconcilable views of man which we may hold. As he pointed out, from the physical and chemical standpoint, "a man is about 70 kilogrammes of *material*, with a certain configuration, properties, and internal movements." From the physiological standpoint, a man is a *living organism* blindly fulfilling its biological destiny. From the psychological standpoint, a man is a *person*, the subject of purposive knowledge and volition. The religious and philosophical thought of the past has begun with this person. The science of today insists upon beginning with the "70 kilogrammes of material." Which is right?

The answer must be that no aspect of the truth must be ignored, and that both parties are right until and unless they begin to deny the truth which the other party begins with. And, as Dr. Haldane pointed out in effect, the reason why we must begin with the "physical and physiological accounts" is that very often we can get no further. Therefore this "physical and physiological account of man" can never be dispensed with, and the more complete we can make it, the better. *But* if our "physical and physiological account" not only stops short of the mind, but declares that the mind is a fiction, of which no evidence is found when we are dissecting the bowel or staining layers of the brain, then the half-truth we have found becomes worse than any ordinary lie.

From the first point of view, physical and physiological which throws its modest light on the genesis of Hamlet by telling us that Shakespeare was three parts water the behaviour of a man depends on his physical environment, and on the blind physical or physiological processes occurring round and within his body; his perceptions and actions and his continued existence depend absolutely on the material and energy coming to him from the environment, and on the bodily structure transmitted to him from his parents. From this point of view— well illustrated in Professor Schäfer's presidential address of 1912 no independent mind or soul can be distinguished, all psychical activity is dependent on the body and its physical environment, and is apparently a mere accompaniment of physiological changes.

But from the second point of view, which is that of everyday belief, of first-hand experience, and also of psychology, a man is a personality, consciously and purposively, with greater or less success, controlling his body, and through it the surrounding environment. It is this idea of man as a

conscious, individual, purposive personality that we are here trying to reach and define, but we cannot deny that this idea clashes with the more "scientific" one which we have been mostly discussing hitherto.

If we conceive of man as a free soul, doing what he will, we are faced with the hard facts of bodily machinery, nervous structure, inherited instinctive tendencies, which seem to be the real mechanical master, the chains and levers, of the mere puppet, man. But if we thereupon adopt the "physical and physiological account" as the whole truth, proclaiming ourselves materialists, and declaring man to be merely "70 kilogrammes of material" moved by physical and chemical forces, we find ourselves hopelessly unable to explain purposeful and intelligent behaviour. Our theory breaks down just when it is required to explain what is obviously the most characteristic and human attribute of man. So clear is this that, if we think it necessary to choose between the two opposed views, we shall end by accepting the view of psychology and of every day.

The Duty of Equal Study of Mechanism and Psychic Life in Man

In Dr. Haldane's words, man, as a conscious individual personality, is at least far less of a fiction than as the blind machine described by the mere anatomists and physiologists who "murder to dissect," and then say the thing is not really alive at all, but only a marionette.

Here we cannot solve the riddle which has baffled all deep and honest thinkers since thought began. But we can endeavour faithfully to set down *all* the aspects of truth, so far as it is known. Our proper course is to take the contribution of physiology, and value it for what it teaches, while declining to accept the estimate put upon it by those who are physiologists and nothing more. That, we shall find, has been the consistent method of the great thinkers, from Aristotle to Kant and Spencer and Bergson. They have learnt all they could from physiology, and have used it as part of their equipment for the study of what no microscope will ever reveal, nor knife dissect.

Let us then proceed with our study of man and of his behaviour. Hitherto we have scarcely transcended the "physical and physiological account" of him. We have seen his nervous system, and the machinery of sensation and of inherited instinct, with certain correlated facts of the *psyche* called emotions; and these all are what they are and do what they do in virtue of their inherited structure, and without our requiring to call in explanation anything that can be called the *Ego*, the Conscious Personal Will of Man. Let us still proceed with our observation of his behaviour, and we may yet find Man and his Will at the end of our search.

The Part Played in Man by Intellectual Conviction, Instinct, and Sympathy

We saw that the notion of man as a purely reasonable being, who acts only from and upon intellectual conviction, is not warranted by the facts; and that, indeed, there is no reason why intellectual conviction should cause anyone to act in any way whatever, unless he has some interior purpose of his own to fulfil. We act, it was found, very largely by instinct and emotion, on planes largely beneath the level of our self-conscious will, and often for vital ends which our intelligence does not even recognise, and which may be fulfilled quite as well, or better, for our unconsciousness of them. Now, having defined the primary instincts and emotions, we must ask whether there are any native, natural tendencies of our behaviour still beneath the level of conscious will. On no account, if we can help it, must we leave out any such facts, before we try to understand the Self who stands above and upon them all.

We saw that, besides the emotions, there is a fact called sympathy or the sympathetic induction of the emotions, whereby the spectacle of emotion in someone else inclines us to experience the same emotion and to act in the corresponding instinctive way ourselves.

The Part Played by the Non-Rational Process of Suggestion

To this fact of sympathy, which explains much of our behaviour, must be added a second, called suggestion, a word which is nowadays very familiar to the public ear, because of the interest aroused by the phenomena of hypnotism, which depend upon suggestion. But though the action of suggestion is most conspicuous when we see it at work upon the extreme suggestibility of the hypnotised person, who will accept any proposition that is offered to him, and receive any suggestion, it is now known that "suggestibility," to use a clumsy but convenient word, is a normal fact of the lives of all of us, in some degree.

The mark of suggestion is that it is a *non-rational* process. Sometimes we accept

ideas because, on rational examination, we are convinced of their truth, but we also accept ideas (and act upon them) by suggestion, for some other reason than our logical satisfaction with them. It follows, of course, that the critical, highly educated, and intelligent adult is little suggestible, while the child, the savage, the peasant, woman rather than man, *on the whole*, are more suggestible.

Once we realise what a part suggestion plays in human behaviour, and how important it is in the ordinary lives of individuals and communities, as well as during "revivals," or during hypnosis, we require to define the factors which affect it.

The Heightening of Suggestibility While We Are in a State of Quiescence

First we note that suggestibility is much heightened in many states of the brain that are not its normal, "wide-awake," "all-there" state. During partial sleep, "day-dreaming," hysteria, and the actual hypnotic state, suggestibility is greatly heightened. It is also heightened by sheer fatigue. The extreme importance of fatigue in this connection is illustrated in too many of the religious impositions, exercises, and penances of the past, where the fatigue of the devotee, induced by an all-night vigil, or some such strain, has rendered him impotent against the practice of suggestion.

Suggestibility is further affected most markedly by our degree of knowledge and conviction on the subject in regard to which the suggestion is made. This fact has been conspicuously illustrated by the experience of many physicians who have lately studied and practised hypnotism for therapeutic purposes. In order to induce the hypnotic state, in which therapeutic suggestions—for instance, that the patient will sleep well and deeply at ten p.m. that night—can be successfully made, the patient must in the first place be suggestible enough to "go under" the operator's control.

The Power of Prestige in Making Suggestion Effective

The most distinguished practitioner of hypnotism in this country once told the present writer that, when he began his study of the subject, and used to hypnotise his patients in a northern town, he never had any difficulty. But now, in London, patients are sent to him from various parts of the world who have read all the treatises on the subject, are acquainted with every variety of its technique, could themselves recite the causes of failure and the conditions of success in hypnotic practice—and in vain does he try to hypnotise them. They know too much.

If and when he does succeed, it is because of the third factor which powerfully affects suggestion, and that is the impressive character of the source—the oracle, the sacred volume, the famous doctor, the renowned healer—from which the suggestion emanates. A great reputation is thus the very means by which a reputation is maintained and justified; and if any reader of these pages supposes that this proposition applies only to men who practise medicine, and not to men who practise anything else, he is really too simple to live. In fact, half the meaning and value of reputation, whether for healing, or writing, or speaking, or anything else, depends upon the "prestige-suggestion," as it has been called, which the reputed person can use. You go in to the great doctor, or he enters your bedroom—already you are nearly better. You go in to bat against the great bowler, and already you are practically out. "Prestige-suggestion" always was one of the great rulers of the world; and though its methods are seldom so crude today as once they were, it rules us all yet.

The Influence of the Power of Suggestion Upon Human Beliefs

We know the importance of "making an impression," and so does the doctor who, having perfect sight, wears heavy gold-rimmed spectacles, the judge with his wig, ecclesiasticism with its processions, and royalty with its crown. Far more than half the history of human beliefs has depended upon and is today being made by the power of suggestion; and the most successful demagogues, orators, propagandists, religious leaders, leaders of political parties, editors, generals, swayers of men in general, are those who subconsciously or consciously realise that the supposed predominant rationality of man is a myth, and who suggest the crowd into the desired course, while others reason and are routed. This fact has, of course, no reference to or dependence upon the rightness or wrongness, the reasonableness or unreasonableness, of the ideas communicated. Suggestion is simply a great mode of psychical power, potent alike for good or for evil.

A curious form of suggestion, which most of us must have observed, is called *contra-su*[illegible] and here the person affected sin[illegible]es in the opposite direction to th[illegible]h the suggester proposes. The

typical illustration is that of the pig, which is supposed to be taken to market by having its tail pulled homewards. Many people are to be met who will always take up the opposite position to any that is suggested to them, whatever the suggestion may be. They act under the influence of the instinct of self-assertion; and so far are they from accepting what others say that they will immediately attack it. This "contrariness," as parents and nurses call it, is often observed in children at certain stages in their development. The adults who display it most pride themselves on *not* doing what other people do, and can, like the traditional pig, be persuaded into any course of action desired if only its opposite be strongly suggested to them.

The Startling and Non-Rational Action of Contra-Suggestion, or Contradictoriness

Contra-suggestion is often exhibited towards special individuals or sources. There are certain such individuals or sources, for each of us, whose assertions, proposals, advice we, as we say, "instinctively distrust," and other people feel just the same way about ourselves. Certain readers of, say, these pages may feel that each sentence arouses a desire to controvert it, to quote exceptions, to show fallacies. The power of contra-suggestion often takes startlingly non-rational forms, convincing all of us that it is essentially a non-rational fact of the mind. Thus Herbert Spencer (in whom himself contra-suggestion was strongly aroused by many people, as it is in most men of strong intellect and self-confidence) records in his "Autobiography" the fact that he visited Carlyle, who was so prone to contradict what was said to him that, as Spencer proved, he would contradict with scorn one of his own propositions when it was advanced by another man.

The Extraordinary Effect of Clothes in Relation to Suggestion

The case is not unique. Most students of controversy can learn a lesson if they will avoid contemporary controversy in which their own passions are excited, and go back to any typical controversy of a generation or a century ago, on some subject of which they are competent to judge. Usually they will marvel how such famous and clever and admirable men could have said what things they did, and have failed to see things which were plain and indisputable. The only conclusion is that, unless we are exceedingly careful with ourselves in controversy, we soon come under the sway of parts of our nature—such as "contra-suggestibility"—which are not reasonable; and then, alas! we use or abuse our reason in the interests of those non-rational and truth-disdaining parts of our being.

The extraordinary importance of clothes in relation to suggestion and contra suggestion has been observed and commented upon a thousand times; and the part it plays in our lives even now is scarcely to be credited until we begin to look for it. Even those who disdain decoration usually make their disdain so evident, their opinion so decided, their liking for utility so blatant, their reticence so loud, that we see the influence of contra-suggestion upon them, and their desire to impose *their* suggestions upon us. But, indeed, none can wholly, or wholly and always, escape from suggestion; and it is amusingly recorded by a man of strong and exact intellect, the late Sir Francis Galton, that when he had to be interviewed by his superiors he always found himself much sustained by putting on his best clothes - a course which he advises for timorous people in all such circumstances.

Illustrations of Suggestion in Dress, Songs, and Sentiment

In fact, we all know that, ludicrously absurd and non-rational though the fact be, our own clothes make powerful suggestions to ourselves, so that we behave differently, estimate ourselves differently are different ?—in evening-dress, in our pyjamas, in bathing-dress, in academic hood and gown. The whole business of "dressing up," which all men and women do everywhere, and have always done, for all imaginable occasions, depends very largely upon suggestion.

Those to whom these facts are subconsciously known, who have, as we loosely say, the "instinct" for these things, never fail to employ the suggestions of dress for their purpose. The Salvation Army officer, in his red jersey, and with the name of his Army in his ears, has suggestions of courage and efficiency and self-sacrifice constantly being made to him. The nurse whose cap and apron are clean and neat and characteristic of her profession feels that it is "up to her" to play the part for which she is dressed. The Boy Scout is fifty times more a Boy Scout because of the suggestions which his clothes communicate to him; and the day on which 'bus-conductors are put into uniform finds them brisker and more polite. So much for the

suggestive power of mere clothes. But if we were to proceed to show how the behaviour of mankind is affected by the suggestive power of words, songs—"Let me make a nation's songs, and who will may make its laws"—hymns, battle-cries, it would be necessary to write a treatise on history and another on literature. "Man lives not by bread alone, but principally by catch-words," said Robert Louis Stevenson; and now we begin to see what suggestion means in the affairs of men. But this is a mere beginning, as we discover when we begin to study the "psychology of the crowd," as it has been revealed to us by M. Gustave le Bon, the brilliant French writer, and by other students.

A Study of the Native Tendency of the Mind to Imitation

Closely allied to suggestion, so closely that the two cannot always be sharply distinguished, and are, indeed, treated together by such a great psychologist as M. Tarde, is the native tendency of the mind which we call imitation. By many writers in the past this has been looked upon as an instinct; and such famous American students as Professor Mark Baldwin and the late Professor James definitely accepted the phrase "the instinct of imitation." But, with the deeper understanding of instinct and emotion which we owe to Dr. McDougall, we must distinguish between the *specific* instincts, each with its correlated emotional state, and such *general* tendencies of behaviour as are summed up in the three words, sympathy, suggestion, and imitation

Certain imitative actions are clearly due to sympathy, or the "sympathetic induction of emotion," as we defined it in the last chapter. One child cries when another cries, because the similar emotional state is sympathetically induced in the second child, and so it seems to imitate the action of the first. Obviously this is not the pure "imitation" which so many writers have discussed, and which we shall proceed to define in a moment.

The Contagious Character of Emotion, Especially in Crowds

But this class of so-called imitation, due to the contagious character of emotion, is an important fact of human life, and especially of the phenomena of men in close aggregation. We see it in the disciplined assemblage of a regiment or a Parliament, but above all we see it in the behaviour of crowds, which have repeatedly done things entirely impossible to any but a very few of their members, under the influence of this kind of imitation. Sometimes these acts are creditable, but more often they are the reverse—hideous, cruel, useless, mad, irresponsible. The tragedy is that, as M. le Bon has pointed out, the psychological level of behaviour in a crowd tends to correspond to that of the lowest type of individuals composing it.

Thanks to the recent analysis of this subject, we can now offer a better explanation than M. le Bon's of this fact which he has so well described. It is the lowest type of individual who exercises least self-control, whose emotions are therefore most visible, and therefore most liable to spread throughout the crowd. Ten men in the crowd feel pity, which shows itself in no more than silent tears, if so much; but ten others feel the lust of cruelty, which shows itself in shouts and acts too easily echoed and imitated. Hence the horrors of a French Revolution in the eighteenth century, or the imbecile folly of destroying an Irish sanatorium in the twentieth.

Other forms of imitation may briefly be mentioned. We see a child, having observed the gestures or gait of another, or of an interesting adult, imitating them.

The Spontaneous Imitation of Movement by the Young

The *idea* of the movement observed, or the tone of the voice heard, enters the mind, and we are moved to perform a similar act ourselves—this being an example of what Professor James and other psychologists have discussed under the name of ideo-motor action—action following immediately upon the presentation of the idea of it. This tendency of the mind, and especially of the young mind, is very important in the production of similarities of speech, gait, gesture, grimace, and so forth among people who live together. Not a few students of psychical heredity, neglectful of the importance of preliminary study in psychology, have described such facts as evidence of heredity, when, indeed, they are evidence of nothing but imitation. The same criticism is necessary for those assumptions as to racial and national characteristics which we all make with such confidence and variety. No one can doubt that racial differences exist, but before we begin to define them we require a psychology that has distinguished between, say, such an inborn fact as the tendency to imitate, which may show racial differences in intensity, and such consequences of that fact

as may be acquired by any child of any race from those among whom it lives.

The reader will now perceive a very good reason why we have discussed suggestion and imitation after our account of the emotions, and of the fashion in which they are induced by sympathy. In these three words, none too difficult or unfamiliar, we have expressed the three great forms of mental interaction. Man is everywhere a social being; and as a social being he behaves largely under the influence of other men, who include not only the living, but the dead, in virtue of the three facts called sympathy, suggestion, imitation.

The Dependence of Mental Interaction on Sympathy, Suggestion, and Imitation

Human life and society would be quite different without these three facts, none of which has any relation to the idea of man as a reasoning creature. That is to say, if these three facts were omitted, so that men influenced one another's behaviour by means of reason, by logical argument, and by that alone, none of us would know where we were; past history would be incalculably different, and we should all behave so differently henceforth that the most ancient and elementary facts of society would disappear. Between this view of the behaviour and attributes of man, and the view which looks upon him as purely an embodied logic, there is a world of difference. It might further be argued that, if the old view were correct, man would turn out to be not more human but less, and that these factors of mutual influence, sympathy, suggestion, and imitation, especially in their influence upon the psychical development of the young, are essential for the life of a social creature. We should give much for a study of the corresponding psychical facts in the behaviour of such pre-eminently social creatures as the highest of the Hymenoptera, but there seems no possibility of our being able to do more than infer from conduct what must be the psychical influences to which, for example, the worker-bee submits herself.

The Native Tendency for what is Repeated to Become Habitual

We now proceed to look at a few other native tendencies of the *psyche*, witnessed in ourselves, which are not specific, like the true instincts, but are none the less natural and potent. One of these is the exceedingly familiar "law of habit." The word, as we have seen, is only just beginning to be exactly, and therefore usefully, employed in psychology. What we correctly call "a habit" is something which is *not* native, but acquired—for instance, the habit of spelling as we do, the habit of pronouncing the consonant R as we do it in this country, with the fore part of the tongue, or as the French do it, with the back part of the tongue. The latter instance is evidently a pure case of imitation, followed by the establishment of a habitual mode of action, which is not native to the individual, nor a racial peculiarity, but something acquired. The one native part of the habit thus acquired is *the native tendency for what is repeated to become habitual.* That is the natural fact of the mind and the body, and it plays a most important part in our lives. In Dr. McDougall's admirable statement, "This is the great principle by which all acquisitions of the individual mind are preserved, and in virtue of which the making of further acquisitions is rendered more difficult; through which the indefinite plasticity of the infant's mind gradually gives place to the elasticity of the mature mind."

The reader who is familiar with psychological text-books, such as those of Professor James, which have found so many readers, may expect at this point a long discussion of habit, a favourite theme of psychologists.

The Loose and Inaccurate Use of the Term "Habit"

But in our present discussion we are, above all, seeking to effect that preliminary chemistry of the mind, that analysis of it into its ultimate constituents, by which alone psychology can progress in the twentieth century, as chemistry did in the nineteenth. We want to find out what are the native elements in the constitution of that infinitely complex structure the mind of man; and when that task is completed, which will not be for many years to come, we shall be able to proceed scientifically. Till then, our discussions of the "law of habit" are apt to be very loose and inaccurate, because we are quite certain, before long, to be mixing up entirely different things, which we have failed to distinguish; and that is the very mark and sign of what science is not. There is the elementary fact that what has been already done, or felt, or perceived tends to be more easily done, felt, perceived, in virtue of the native tendency called habit; but when we discuss drug-intoxications as habits, the need for sleep as a habit, the expression of any of half a dozen instincts as a habit, the recurrent meeting of recurrent need, such as eating, as a habit, we are using the word

to describe a variety of utterly different things, which only agree in the fact that they happen more than once. We are at the level of the so-called chemistry which might describe every liquid as water because it was wet.

Only one other point about true habit need here be made. We have already seen that the actions, perhaps often repeated, but not habits, which we call instinctive actions, are native to the individual. In hosts of instances they can be seen occurring when there has been no possibility of education, sympathy, imitation, practice. Whence came they, in the genesis of the individual, man, bird, dog, or bee? We shall not answer that question—we would give a good deal to be able to do so. But we shall note and reject what may be called the standing answer to it, which is that the habits of the parent become the instincts of the offspring, so that, for instance, the English child *naturally*, "instinctively," pronounces his R's in the English way, and the French child in the French. Whatever is the origin of instinct, an evolutionary puzzle as to which the conventional theories of evolution are notoriously and ludicrously inept, we can point to numberless instances which show that the inheritance of the habit acquired by the parent is *not*, and cannot be, the explanation

The Beggarliness of Our Conceptions of the Physiological Basis of Habit

As for the physiological explanation of habit in the individual, which would also be a physiological explanation of memory, we can use figures of speech, but little more. We can say that a man's mind "works in a groove," we can imagine a sort of "ruts" formed in the brain by repeated passage of the same impulses, and, in the case of the growing brain, we can suppose that the actual microscopic conformation of part of it may conceivably be determined by the lines which sensation and action tend to take in early years. But any real explanation is far beyond us. In discussing this subject at the 1912 meeting of the British Association, Professor Max Verworn, one of the most famous of living physiologists, showed how beggarly are our conceptions of the physiological basis of memory, and therefore of habit, when we try to state them in exact scientific language. We know nothing about it, though books could easily be written on the subject.

If, now, we set ourselves to compare any two of our neighbours or friends, from the psychological standpoint, in terms of the various facts already described, the instincts, the memory, the power of association, the various habits acquired by imitation or otherwise, we shall soon see that there are very large and salient facts of the *psyche* which none of these words cover or even allude to. We differ in our whole way of looking at things, feeling things, and responding to them, quite apart from any specific feature of our minds, quite apart from our training, or even from what we ourselves regard as the most desirable behaviour and seek to attain.

The Strange Differences Between Individuals that are Indicated by the Word Temperament

There is a something which is deeper, even, than any of the aspects of the *psyche* which we have discussed. It is not character, for that is evidently the product of many things—nay, of everything—and yet this native cast of mind is an important element in character. We call it temperament—a clumsy enough word, but we have no better, nor even a single synonym for it in our language, so far as the writer knows.

The familiar forms of speech preserve to this day those theories of temperament which the ancient world invented; and though we reject them, on the whole, we see some truth in them. We talk of a man as sanguine, as apt to take a bilious view of things, as phlegmatic, or as inclined to melancholy. If we examine our language, we find that we have attributed the man's temperamental type respectively to blood, bile, phlegm, and black bile. In other words, the man whom we now call an optimist was regarded as owing his temperament to the possession of much rich blood, while the pessimist was a man in whom the bile had turned black, thus giving him his black view of the world. Similarly, we talk about the "jaundiced eye." Now, the most recent physiological inquiries have shown, on the one hand, that the precise details of the ancient theory were inaccurate, and, on the other hand, that the theory in general was not the truth, but a very important part of the truth.

How Far were the Ancients Right in Referring Temperament to Bodily Chemistry?

In the leading asylums and mental hospitals of the world, and in many psychological laboratories, this partial dependence of temperament upon the bodily chemistry is being worked out. Other than mental diseases also furnish us with hints which may some day lead to definite knowledge—as, for instance, in the happy frame of mind which we usually see in phthisis, and

which was long ago named the "spes phthisica," or phthisical hope. Probably there is not an organ or a sequence of chemical processes in the body that does not contribute in some degree to the chemical basis of temperament.

But temperament has many forms other than those which we call sanguine and phlegmatic. One of the most notable and important of all the differences between us consists in the temperamental tendency which inclines some of us to look more upon the world outside, not thinking of our own bodies or our own selves, and others of us to be brooding, introspective, hypochondriacal, and inclined to lines of thought that lead to religious theories and speculations upon, as a rule, the vanity and futility of existence.

The Profound Effect that Individual Temperament has upon Human Thought

In general, it may be said that the former habit of mind, which we may call objective, is associated with a well-balanced and easily working body, which is not constantly calling our attention to it, while the subjective habit of mind is more inclined to be associated with a less smooth and inconspicuous working of the bodily functions.

A single illustration will show the immense practical importance of these differences. If we take, for instance, the Christian religion, and look at a few of the great names or sects, past or present, which it affords, or if we compare different people who profess it, we observe that one and the same religion, as preached by one man, is full of hope, comfort, promise, a stimulus to work, to enjoyment, to progress, while another man expresses it in terms of menace, fear of the hereafter, contempt for this world and all it offers, disbelief in progress, and disapproval of every manifestation of joy.

Will Study of Temperament Help Men to a Truer Estimate of Truth?

Both men are absolutely sincere, both go to the same source, and both interpret their religion as they honestly feel and believe it. Why this extraordinary and quite irreconcilable contrast between them, so that the religion of one man is the "worship of joy," and the religion of the other man is the "worship of sorrow"? Native, ineradicable difference in temperament is the explanation. They each see their religion through their temperament, as the painter's art is said to represent "Nature seen through a temperament." But the modern psychologist cannot be silent when he has made this statement. His study of temperament in health, and in disease of the mind, in asylums today, and in the biographies of the great writers, optimists and pessimists, of the past, entitles him to say that the objective, active, hopeful temperament is usually and closely associated with the normal, healthy state of man, and that its opposite is usually, or invariably, associated with disease or disorder of some kind or other. Such an observation may help us to determine which of the two views is true.

We all notice variations of temperament in ourselves under varying conditions of sleep and fatigue, hunger and repletion, cold and warmth, pleasant and unpleasant or tiresome companionship. The physician observes other differences, in a given individual, according to certain states of health and disease, as we have seen. But the fact remains, that, on the whole, and with these modifying factors, the temperament of any one of us is part of his native endowment, which he cannot alter by his will, and which he must make the best of.

Temperament Unchangeable Alike in the Child and the Man

It is the business of every wise man to try to understand and allow for his own temperament and that of everyone with whom he is concerned; and, above all, to realise that it is as useless to assume that people's temperament can be changed or need not be allowed for as that, by taking thought, a man can add a cubit to his stature. The importance of these considerations is none the less when we consider the psychical development of children. One child may be taught about the "unpardonable sin," the "worm that dieth not," and be allowed to read whatever it pleases. Its temperament is such that no harm will come to it. Another will accept and brood over such ideas, will read and re-read and remember gloomy poems or autobiographies or stories; and some day, perhaps a few weeks before an examination which has added the last touch of strain to the mind, the child's body will be found hanging dead from a rafter, or at the bottom of a canal.

So much for temperament, one of the most important facts of the *psyche*, and for the behaviour of man. Let us not confound it with *character*, of which it is an important constituent, but fortunately not the whole. Our temperament is part of our heritage and endowment, but our character we can in large degree make.

THE PATHWAY OF OUR FOOD

The Need for Establishing Rules for the Regular, Unconscious Working of the Body's Mechanism

THE PROTECTIVE POWER OF DENTISTRY

FAR more important than most of our discussions about the kinds of food is the proper care of the alimentary canal, which has to deal with the food. If the machinery be in good order it will get value out of almost anything; if it be out of order nothing may be of any value at all. At and in the very mouth of the alimentary canal are the teeth, and a primary condition of health is either to have sound teeth or, at the very least, to have no unsound ones. For the first of these alternatives no prescription can surely avail. Heredity has too much to say in the matter. If we happen to belong to certain of the backward races, we shall almost certainly have thirty-two perfect and unassailable teeth. If our heredity is more fortunate in other respects, it will probably be less fortunate in that. We therefore cannot promise ourselves that the best care in the world will preserve our teeth, or be warned that the utmost neglect will hurt them —"it all depends." We all differ in our chemistry as in our faces. Hence the kinds and number of bacteria that can inhabit our mouths differ also, according to the particular character of the secretions which our mouths produce. Upon this, essentially, the fate of our teeth depends. If they decay, it is because certain microbes produce acids which slowly dissolve the salts contained in the enamel covering of the teeth; if they survive, it is either because the mouth will not allow such microbes to exist in it, or because it produces such alkaline secretions as neutralise the bacterial acids. There are factors at work here which we can only very imperfectly control. But what we can do is eminently worth doing.

It may be doubted whether the students of the chemistry and bacteriology of the mouth have yet found out the exact agent which destroys our teeth. It is, no doubt, something derived, or often derived, from sugar, though, even so, we know now that one may take abundant sugar and do one's teeth no harm. Probably the finest teeth in the world are those of, say, West Indian negroes, who suck the sugar-cane all day long and every day. Nor are we clear as to what the sugar yields when microbes do attack it—as they doubtless do not in such cases.

One thing is certain, however. It is that no one should permit himself to go about with even a single decayed and uncared-for tooth. The decayed tooth is, as such, a source of danger. We may argue as we will whether it should be removed, or repaired, and whether, if removed, it should be replaced. The one certainty is that it should not be allowed to remain in a state of decay. Twenty years ago, when dentistry was a sort of department of artisanship, and had no relation to general medicine and hygiene, the decayed tooth was not seen to matter—at any rate, if it was not seen it did not matter. But nowadays the mouth is understood to be part, a most important part, of the body; and dental hygiene and surgery are part of the general question, just like, say, the care and treatment of the eye or the throat.

Dental caries is due to microbes, whose chemical products defile the odour of the mouth in which they are permitted to thrive. These products tend to be swallowed, of course, and they are to be looked upon as poisons. If a child or an adult has bad teeth, mastication will be imperfect; the food will go, inadequately prepared, into a stomach which is also being poisoned by foul products from the mouth. This is the root-cause of indigestion in hosts on hosts of cases, and their treatment and cure are the simplest things in the world once we grasp their nature, as we usually fail to do. No adult and no child should be permitted

to suffer from these risks. But if we note that about 90 per cent. of the children in our elementary schools have carious teeth, that this proportion persists from year to year, that "dental clinics" have hardly yet been heard of outside Germany, except in Garden City and a very few other places, we shall agree that, if dental caries really matters, there will be plenty of work for hospitals and doctors and Insurance Acts in the future.

The Cures that May be Effected by Making the Teeth Sound

It matters far more than merely in that a clean mouth, containing no foul teeth, protects us from a constant source of blood-poisoning. At any rate, it is enough to know that many cases of ordinary anæmia, with indigestion and all the attendant symptoms, may be cured by the dentist's steel when even the physician's iron fails altogether.

But there is much more to say. The commonest cause of neuralgia and headache, by far and away, is dental caries, especially in the upper jaw. The doctor, if he still exists, whom you consult for neuralgia, and who prescribes phenacetin or such drugs while neglecting to examine or inquire after the teeth, is a man to be shunned as irresponsible or incompetent. No one averts or cures so much neuralgia as the dentist. It is an absolute and infallible rule, which admits of no exception, that no one who suffers from any degree of headache or facial neuralgia should do anything else—least of all, take any drug, advertised or prescribed by doctor or chemist—until he or she has first freed the mouth from the presence of a single decaying tooth. It is one of the penalties of commercialism, and of the ignorance and folly which still largely govern our education, that we should send the nation to school for a septennium, in millions at a time, without making it impossible for a single boy or girl to leave Eton or a "board school" without knowing that no one must touch drugs for headache or neuralgia until the dentist has discharged him—and not then.

The Openings Offered to Infection by Decayed Teeth

But the blood-poisoning, with its anæmia and indigestion, and the neuralgia, are still the least of this question. The most important fact about a decaying tooth is that it is an invitation to infection. Valuable and alive though the tooth is, it is not a vital organ. If the microbes that enter it merely stayed there, we should only have the tooth, at worst, to regret. We know, of course, that they sometimes go further, and then one has a gumboil. These are very "trying," but not very serious. Occasionally the bone of the jaw may itself be attacked, or an abscess may form within the cavity of the upper jaw. Care of the teeth averts these risks, which are more or less obvious, but modern pathology raises entirely new considerations.

The healthy body is well protected against microbes. No microbe can pierce unaided the outer layer of the skin. Probably the same is true of the lining of the mouth, and the surface of the healthy tongue and tonsils. The hydrochloric acid produced by the healthy stomach is a splendid and invaluable antiseptic. Risk begins with a *breach or degeneration of surface.* This may be minute, even microscopic, for so are microbes, but it makes all the difference. Thus in our study of the routes of infection, above all of tuberculous infection, our search begins to be narrowed down. We most of us swallow millions of tubercle bacilli in our milk, but they perish in the hydrochloric acid of the stomach. Yet certainly the bacilli in milk do gain entry to our bodies, and especially to our children's bodies. These cases block the doors and cram the waiting-rooms of every general hospital in the country.

Where Signs May be Seen of the Entry of Infection

Over and over again the infection shows itself in the neck. Why should the glands of the neck suffer so much, and whence does the infection reach them? Why, also, should the apex of the lung, its highest point, be so commonly the first to be infected in consumption? The answer is that we do not properly guard the portals of the body. The healthy mouth, nose, and throat can take care of themselves, and of us. But the decayed tooth will convey the microbes of tubercle readily, by means of the lymphatic vessels, to the lymphatic glands in the neck, and also to the lungs themselves. The diseased throat, crowded with adenoids, and with swollen, futile tonsils, is a further invitation.

The time must clearly come, therefore, when, besides—or instead of—spending millions of money on the cure of consumption, we shall deal with the 8 per cent. of our school-children who have adenoids, and the 90 per cent. who have bad teeth. Meanwhile, the facts are here laid before the reader, for his health and that of those for whom he may be responsible. If you want

to keep dangerous people out of your house, you shut the door. The door of one's bodily house has to be opened, to eat if not to speak, and enemies are constantly admitted in this fashion. But what could be a more elementary precaution than to see that no morbid openings lead from mouth and throat into the body itself?

It follows that the value of good dentistry can scarcely be overrated. The contrast between good and bad dentistry is at least as marked as in any other profession, and the best dentistry of today is extraordinarily good--a new thing in the world, like Listerian surgery, to which it is much indebted. One would require to be very poor indeed in order to be unable to afford the fees of a first-class dentist, even though each visit cost half a week's income, for the possession of good teeth, or, at least, the non possession of decaying teeth, is a *sine qua non* of health. The cost of the good dentist's work has to be reckoned as against the amount of life which it provides for us. Further, the good work endures, as bad work does not.

The Bad Economy of Grudging the Cost of Skilful Dentistry

Yet on every hand people are to be found who grudge no ordinary expenditure on clothes that perish, amusements that are no sooner come than gone, luxuries to eat and drink and smoke, and even chemists' bills on a large scale, but resent having to pay their dentist, and, indeed, often forget to do so. But in terms of life good dentistry is probably the cheapest thing in the world. Let us add that good dentistry is not necessarily the most showy, though people do not grudge paying for visible gold and porcelain, and so forth, who resent the payment of far smaller fees for fundamental work done under the gum, or in the canal of a tooth, or with materials which look less expensive, but are much better for the teeth in question. Therefore let us beware of the so-called "American dentistry" not practised, of course, by the best American dentists—which simply looks upon a tooth as a hard, inanimate object which is to be dealt with on mechanical lines. A dental-mechanic of this school, in order to get access for his unquestionably skilful, elegant, and showy technique, is willing to wedge teeth apart to almost any extent, being totally unaware that he is thereby damaging the vital connections of the root, injuring delicate blood and lymph vessels and nerve fibres, so that in time the root will atrophy, and be unable to support an artificial crown should one be desirable at a later date. We owe much to the mechanical resource of American dentists, and notably to the clever instruments they have invented, but their fashion of forgetting that a tooth is a living thing must be condemned, as also the stupidity of people who will pay freely for what looks well, but grudge paying for what lives and lasts well.

The Deterioration of Teeth Partly a Consequence of Unnatural Diet

But the savage and the dog need no dentistry; and when we ask why we should, it has to be admitted that our teeth are not what they should be. There is something to be said for the view that our tendency to dental caries is inherited. Time was when the possession of good teeth must have had some value in the struggle for existence. Those who had bad teeth would tend to disappear. But dentistry and modern cooking have reduced the importance of naturally good teeth so much that many people with naturally non resistant teeth now survive and have children like themselves. At any rate, there is no doubt that cooking, and the selection of food, in modern days have interfered with the need for thorough and natural mastication, and that the teeth are thus deprived, in early years especially, of the exercise and ample blood-supply which they require.

For some years past, Dr. Sim Wallace, a distinguished dental surgeon, has studied and written on this question. In direct opposition to the orders and advice of the Fletcherites, who object to the presence of any non nutritious substance in our diet, Dr. Wallace and those who think with him declare that we should take considerable quantities of fibrous food, of which a high proportion is quite indigestible and innutritious, in order to keep the teeth clean in a fashion superior to that which any toothbrush can effect.

The Kinds of Food that Should be Eaten First and Eaten Last

In a multitude of counsellors there is said to be safety, but there may also be confusion. Here, at any rate, without reference to any questions of dietetics, are the lists lately given by Dr. Wallace at an important Congress. On the question of teeth at school, he said "There is a new principle, which is still neglected by most of those in authority at schools. It is of primary importance that the meals shall be so arranged that the mouth will be in a hygienic state on finishing the meal." Here

are the examples of cleansing foods which should end a meal, and non-cleansing foods which should not be eaten last, as given by this very careful student.

Cleansing Foods	Non-Cleansing Foods
FISH	SWEET BISCUITS
MEAT	CAKE
*LETTUCE	BREAD-AND-JAM
CELERY	MILK-PUDDINGS
CRUST	PORRIDGE
TOAST	PRESERVED FRUIT
FRUIT	CHOCOLATES
TEA	COCOA
COFFEE	

Dr. Sim Wallace's books on dietetics in relation to dental caries and to allied forms of disease should be studied by those who are specially interested. There can be little doubt that his contentions are substantially correct, and that anyone, who does not brush his teeth after every meal would at least do well to arrange his meals in adequate correspondence with the list given above. The last five items on the first list can surely, between them, afford us the wherewithal to protect the mouth at the end of any meal.

The Ruinous Habit of Giving Children Soft and Sweet Foods at Night

There should certainly be no such thing as dental decay due to our permitting a child to go to sleep with the necks of its young teeth in the deadly embrace of chocolate or soft biscuit. Heavy and long-maintained are the penalties for such folly; yet many a loving parent who lives for his or her children is guilty of it habitually, though incapable of doing a hundredth part of the harm in any other way. No child should be put to bed with chocolate or soft biscuit in its mouth. If it must have something, let it have an apple, which is good in itself, and cleans the teeth beautifully.

There is no doubt that, in the discussion of dental hygiene, diet is the first thing to discuss; and Dr. Sim Wallace has done good service in insisting that we should not start out with toothbrush and dentifrice until we have considered first questions first. The toothbrush follows, though those extraordinary folk the biometricians have lately made calculations to show that children who use toothbrushes have no better teeth than those who do not. In collections of children such as comprise many who do and many who do not use a toothbrush, it is urgent need that has made many use it who do. Comparative studies are worth less than nothing unless one has similar teeth in the two sets of children to start with. But there are right and wrong ways of using a toothbrush. The mere motion of the brush from side to side chiefly cleanses the flat surface of the teeth, which is least in need of attention. The proper motion is up and down, so as to clear, as far as may be, the spaces between the teeth. Fortunate are those people in whom these spaces are considerable, so that nothing can long lodge in them. One should use the brush almost after the fashion in which a razor is stropped, that is with a rotation, so as really to do the essential thing, which is to *clear crevices*.

The Proper Uses of Small Toothbrushes and Simple Dentifrices

The brush should be small, it should not be very soft, for such a brush may simply squeeze material into crevices, nor very hard, except for very fine, hard teeth. The injudicious use of too hard toothbrushes, with side to side motion, and with a gritty dentifrice, is apt to wear away the enamel, especially on the exposed aspect of the eye-teeth; and that is the very last end for which one uses a toothbrush.

The requirements of a dentifrice are simple enough, and very definite. There are many pleasant antiseptic fluids on the market, no doubt desirable as mouth-washes, but they do not have the first necessary qualification of a dentifrice, which is that it should be solid. It must be a powder with a mechanical action, but it must be entirely incapable of scratching the teeth; and probably pumice-stone is to be condemned on this ground. The best dentifrice will be a powder capable of mechanically cleaning but not of injuring the teeth; it will be antiseptic, of course; and it will be alkaline, thus supplementing the action of the alkaline saliva in neutralising the acids of microbic origin which cause dental caries.

A Dental Surgeon's Recipe for Cleansing the Teeth

Mr. W. S. Nowell, M.B., who is senior surgeon to the dental department of the Middlesex Hospital, and whose patients are fortunate, recommends a half-and-half mixture of carbolic tooth powder and powdered chalk. This is quite cheap if one has the sense to do the mixing oneself, and to buy the ingredients in large quantities, say a pound at a time. Mr. Nowell also strongly recommends the addition of a little bicarbonate of soda (baking-soda) to the water in the tumbler when one brushes the teeth at night. This antagonises the destruction of the teeth along the edges of the gums.

Lastly, as regards children, we may here quote the conclusions reached by Mr.

Edmund Wallis at the end of a very careful inquiry communicated by him to a recent annual meeting of the British Dental Association. He found that the serious septic complications of scarlet fever are much more common and severe in cases where the teeth are bad; that the children with the worst teeth are unhealthy in appearance, and below the average in weight, and nearly always below the average as regards their school-work in proportion to their age. He concludes as follows.

The Impaired Physical Condition of School Children Largely Due to Unsound Teeth

"The mental and physical development of the children attending the public elementary schools is much hindered by the wholesale neglect from which their teeth are suffering; their susceptibility to diseased conditions is much higher than it would be if their mouths were kept healthy; and, moreover, should they be unfortunate enough to contract scarlet fever, the probability of their suffering from one or other of the serious complications that frequently follow this disease would be considerably increased. In short, the prospect of a child deriving the full benefit of the instruction provided in an elementary school is much impaired by the prevailing condition of the teeth; and when the children enter upon wage-earning careers, they do so, in a great number of cases, with impaired constitutions, and with a physique unable to cope with the present-day struggle for existence." A few years later these children will apply in large numbers for admission to the Army, and will be rejected by the medical officer on account of their defective teeth. These are facts which may well be considered by the advocates of National Military Service.

We are responsible for the care of our teeth, and then for the care of the bowel. Numerous and complicated processes intervene, but they are, fortunately, beyond our control, and in no need of our supervision. We do our duty to ourselves, or those for whom we are responsible, if we attend duly to the diet, to mastication, to the teeth themselves, and to the bowel.

Constipation the Commonest Malady Due to Modern Abnormal Conditions of Life

This latter problem scarcely arises in the case of those remarkable enthusiasts the Fletcherites, for, as we have seen, they take no innutritious or indigestible food, or practically none, and, having thus reduced the waste matter of their diet to an infinitesimal quantity, which they call the "digestion ash," they need do little more than dispose of it, perhaps only once in a fortnight. The possibility of this depends on the adoption of a very circumscribed dietary scheme; and for the rest of mankind there is more to consider.

The abnormal conditions of our lives are responsible for the attention which so many people require to pay to what should require none. The careful selection of our diet, its careful preparation (all directed towards reducing the quantity of "ballast"), together with our too-often sedentary mode of life—which means that the muscles both of the abdominal wall and of the abdominal organs tend to lose their tone—these combine with the hurry of our lives, making us feel that we must get on to our work the instant after breakfast, so that, in the upshot, constipation is established as by far the commonest malady of the civilised world. Notable testimony to this fact, familiar to all general practitioners, is furnished by the analysis of patent medicines. They are consumed to an amazing extent, and by far the greater part of all of them simply consists of aperient substances.

The Mischief that Follows from Using Aloes as a Regular Aperient

The standard stimulant of the lower bowel, which is aloes, is *the* constituent of the most popular pills and syrups, and so forth. These drugs must not be condemned outright; they are, of course, absurdly expensive, but that doubtless helps, in an unsophisticated world, by providing or fortifying the element of faith or auto-suggestion, which tells powerfully upon the action of the bowel. But they do effectively relieve the constipation of hosts of people; and if their use were strictly occasional, as when the village mother gives her boy "his bath and his Beecham" on a Saturday night, there would be little need for criticism. On the other hand, the action of aloes is too much confined to the lower bowel, and it largely acts by causing congestion of the veins, which is often apt, in predisposed persons, to lead to the development or aggravation of "piles," or hæmorrhoids. No one, therefore, should take aloes in any form as a *regular* aperient. For that purpose, if, indeed, any medicine is to be employed—and no medicine is necessary for the purpose in those who properly regulate their diet—we require a blend of drugs, so as to act gently but equably on the upper as well as the lower part of the bowel. Various "dinner pills" and so forth may thus be compounded,

but their regular use has in it almost something of the discreditable, indicating, at least, that the taker's appetite is either excessive or vitiated. No one who retains the proper, natural love of fruit need ever be in such a plight; but when young girls are educated by fond parents to take champagne at dinner, and to refuse the grapes at dessert in consequence, to say nothing of taking little exercise, we may be assured that their youthfulness and beauty and enjoyment of life will disappear long years before they should do.

The importance of constipation, we need hardly remind ourselves, is not mechanical, but chemical. Microbes appear in the bowel of the infant about the tenth or eleventh day, we are told, and thereafter they are never absent—though, indeed, some special inquiry should be made into the "intestinal flora" of the Fletcherite. If the secretion of the kidneys be carefully examined, we can readily find in it, in cases of constipation, toxic substances which we can prove to have been formed in the bowel. The proof is absolute, then, that these toxic substances have been absorbed from the bowel, have circulated in the general blood-stream going, therefore, to the brain, as everywhere else and have finally been excreted. The theory of auto-intoxication by constipation is thus established.

Dieting Needed with Advancing Life to Avoid Self-Poisoning

This is the key to many of the facts of advancing life in a host of cases. Sir Thomas Clouston, in his splendid book on "The Hygiene of Mind," says on this point: "Vague feelings of organic bodily discomfort interfere with the full enjoyment of life, and mean that the processes of nutrition, and the working of the great internal organs connected with digestion, are not done as well as before, and no longer give conscious satisfaction. This feeling is often connected with a newly developed constipation of the bowels, and with the diminished keenness of the appetite for food." The great student of mental hygiene and disease from whom we quote goes on to say that these symptoms are due to an auto-intoxication which demands a considerable modification of the diet at this time of life. This modification should take the form of reduction, and it is particularly necessary to control the constipation to which he refers.

Doctors commonly lay down the rule of "once a day" for an adult. Let no one suppose that this would suffice for an infant, or that the figure is in any sense absolute. There are hosts of exceptions, in both directions, to it which are consonant with perfect health. Many people double and many halve this frequency. The diet of the individual is a most important factor, for the Fletcherites have shown us how they thrive in conditions of what, with an ordinary diet, would be the kind of constipation which almost imperatively calls for surgical interference.

Whatever the habit be, within reasonable limits—and once in two days is probably the extreme in that direction—at any rate there should be a habit, and it should be adhered to rigorously. This means a healthy education of the bowel as far as its subconscious regulation by the nervous system is concerned.

The Great Importance of Establishing Regular Bodily Habits

We have already hinted at the importance of faith in the control of the bowel, and, indeed, there is no part of the body, nor any function, which is more closely susceptible to nervous influences. The influence of fear, as before an oral examination, is familiar to most people. Now, in these circumstances it is well to establish a sound habit; and while this is easily and quickly done, it is still more easily maintained. In extreme cases of nervous constipation, in persons suffering from neurasthenia or nerve-weakness, actual hypnotic suggestion may often be successfully employed. The hypnotist informs his patient, when in the hypnotic state, that the bowel will thereafter make a regular demand at a given hour, and so it does.

But no one really needs such extreme means for the formation of a sound nervous habit here. Any reader may train himself in this fashion, with the practical certainty of success, even in extreme cases of nervous constipation. The hour, of course, should be after breakfast, when the various movements associated with getting up have begun to wake the bowel from without, and the breakfast has stimulated it from within.

The Need for Making the Use of Aperient Drugs Unnecessary

The smoker, also, has trained himself, as a rule, to be helped by, if not, indeed, to require, his after-breakfast pipe for this purpose. The hour must be rigidly adhered to, inclination or no inclination. Enough time must be allowed for the purpose. This is often overlooked, especially as the business man usually has little time to spare at this hour of the day. The nervous

apparatus may decline to be hurried, and its action may be absolutely arrested by the consciousness of hurry. So are we made. But if a fixed hour is adopted and adhered to, and if a sufficient time is always allowed, the necessary nervous habit can be formed by anyone.

It is vastly superior to the use of drugs, and is applicable in many cases where the use of an irritating and bulky diet would only upset the digestion. Dr. Schofield has told us that on the whole he has earned more gratitude from patients by forming this habit in cases of simple constipation than in any other way. As for drugs, we have already admitted that it is much better to use them than to be constipated, but it is better still not to require to use them at all. Their use costs money; the dose requires to be increased, just as in the case of hypnotics; and very few of those who use them are subtle and careful enough in their choice to avoid doing harm.

The Choice of Diet with a View to the Natural Disposal of Food

We have repeatedly insisted here that it is absurd and impossible to judge a diet merely by its nutritive constituents, and to assume that one food is three times as valuable as another because it contains three times as much protein, or what not. Such judgments are absurd, not merely because we do not yet know enough about the elements of nutrition, but also because our diet has at least two important functions to discharge besides feeding us. As we have already seen, the ideal diet should also be, or include, an effective dentifrice, as in the case of the lower animals; and our dietetic theories must either be "squared" with the dental need or else we must take very special and artificial precautions regarding our teeth. Secondly, the ideal diet must be so contrived as to provide for the health of the bowel, and therefore we now must make a few notes upon diet from what is thus a third point of view.

The Virtues of Porridge, Brown Bread, Crusts, Treacle, and Fruit

For the relief and avoidance of constipation, whole-meal porridge, oatcakes, and brown bread, with its bran, are all to be commended, it being assumed that the digestion will tolerate them. If it will not, the last state of the patient will be worse than the first. Both children and adults should consume the crust of bread and toast. We saw how highly nutritious that is, we have seen Dr. Wallace commend it for the teeth, and now it is to be commended for the bowel. Cutting away the crust of toast is one of those pieces of luxurious folly which have nothing to commend them, no excuse in hygiene, in elegance, or in economy. Then syrup and treacle and marmalade are useful at breakfast, of course. Fresh vegetables are valuable, partly because they supply ballast, and partly on account of the aperient salts they contain. One of the stupidities of our time is the spectacle of people consuming "fruit salts" in large quantities and at considerable expense while they avoid fruit.

It is scarcely possible to eat too much fruit. Everyone should eat some fruit every day. It is valuable for the teeth, for the bowel, and for the blood, and it is the ideal fashion in which to supply one's self with water. Fresh fruit is the best, like fresh vegetables and fresh everything else, but, for the bowel specially, stewed figs and prunes are very useful; and if one cannot obtain fresh fruit, jam at least should be taken. Recent developments in the commerce of diet have been very favourable to national health. The introduction and cheapening of the banana, the enormous increase of the trade in canned and bottled fruit, and the great extension of the "season" of the orange have all helped in the direction of sobriety, of natural action of the bowels, and of the ever-rising standard of public health.

The Value of Simple Fluids Between Meals and Exercise

Often constipation can be much relieved by increasing the consumption of fluid, especially between meals. Milk is somewhat constipative, and buttermilk may sometimes be substituted. It is highly nutritive, and may have some special virtues. Nothing can be less sensible than the too common custom of taking aperient medicines every day, while consuming large quantities of improperly made tea, containing an abundance of that highly astringent (*i.e.*, literally "binding") substance tannic acid. The combined anæmia and constipation which afflict so many domestic servants are largely due to their unwise diet, their undue indulgence in badly made tea, and their lack of exercise. Constipation is markedly opposed by exercise, and especially by those forms of exercise which involve the vigorous use of the abdominal muscles. The reader who follows, in reason, the advice here given can scarcely fail to ensure for himself a healthy acting and active bowel, which shall safely absorb his food into his blood, and no poisons with it.

THE TERRORS OF STEAM BROKE LOOSE

A BOILER EXPLOSION IN THE STOKEHOLD OF A TORPEDO-DESTROYER

THE POWER OF STEAM

Recent Revolutionary Improvements in the Principle and Construction of Steam-Engines

THE WONDER-WORKING OF A PROFESSOR

For more than a hundred years the steam-engine has been the main source of mechanical power on which our industrial civilisation has been built. It has endowed man with a tremendous and easily controlled force, by means of which he has excelled all the fabulous exploits of the giants of ancient legend. No other prime mover can compare with the steam-engine in historical interest, and the fact that it was a peculiarly British invention gives it a special attraction to us. More than once it has saved our country from industrial bankruptcy. It was entirely by means of it that our forefathers were able to get the coal, the iron, and other metals out of which they erected the industrial supremacy they have bequeathed to us.

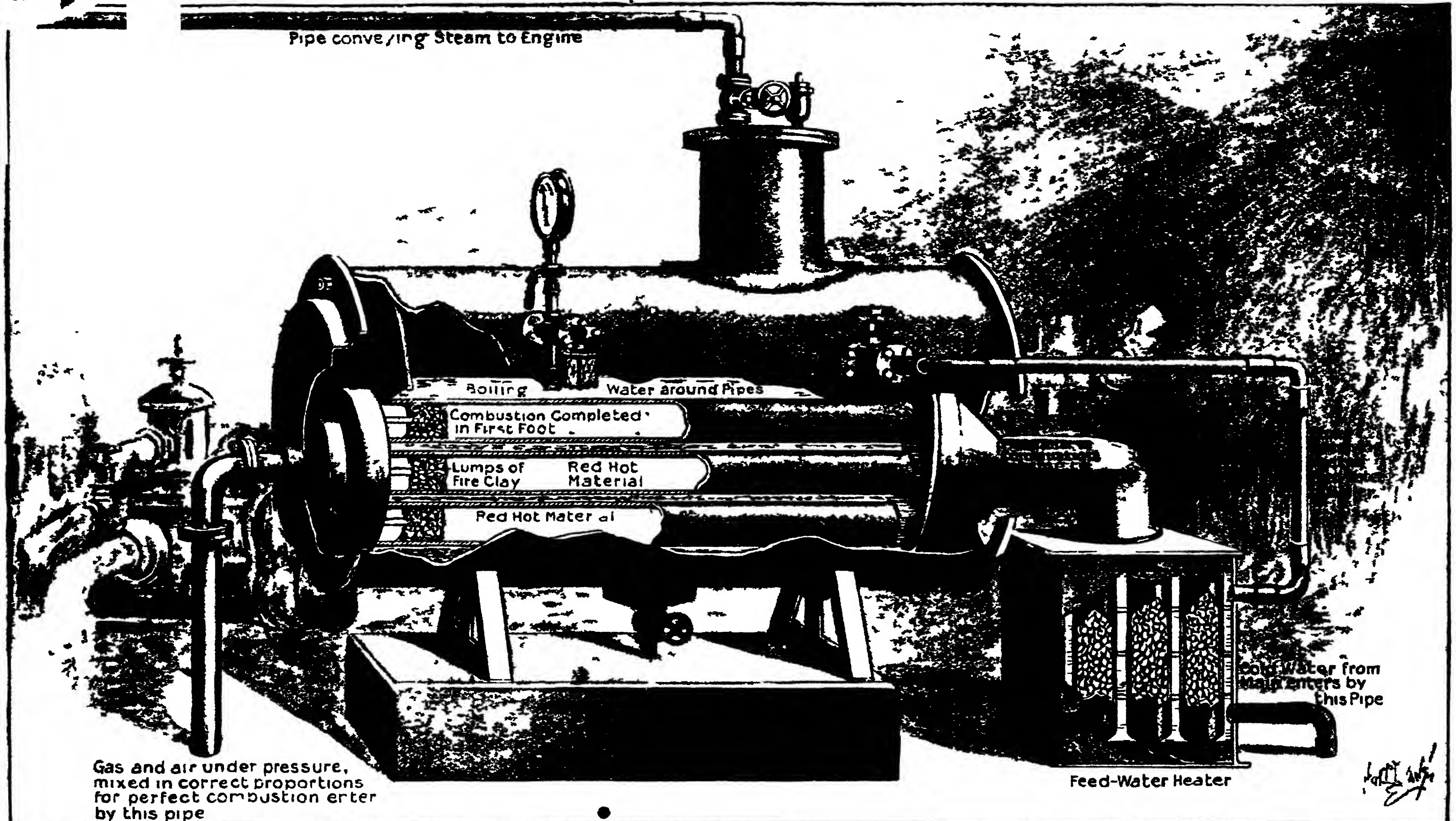
For it was the early steam-pump that saved most of all our mines from becoming unworkable towards the middle of the eighteenth century. Improved and attached to power machinery, it transformed and enormously extended all our chief processes of manufacture. Placed on a ship, and afterwards on a colliery tramway truck, it completely changed the methods of transportation, and enabled us to sell our manufactured products throughout the world, and draw from the ends of the earth, with unheard-of swiftness, new food supplies for our rapidly increasing population.

Most of us or, at least, a good many of us are the children of the steam-engine; that is to say, we should not probably have been born if it had not been invented. In the absence of vast and cheap supplies of fuel and ore and the power machinery for putting these materials to new and larger uses, our island would have remained an agricultural state, with a comparatively limited people. Economic conditions would have prevented that extraordinary density of population which is the distinguishing feature of our large industrial centres. Moreover, we could never have colonised with the unparalleled rapidity that has made the sudden expansion of our race the most remarkable thing in history. Linked to a plough, a drill, a reaper, and a thresher, the steam-engine feeds us. It carries us by land and water; it does all our hard work for us; it manufactures most of the electricity that we use in various ways; it is the force behind the machine tools that construct the steel and iron slaves which, as they grow more and more automatic, tend to emancipate mankind from industrial serfdom, and reduce social inequalities.

For some years lately, however, it seemed likely that the work of the steam-engine was practically finished. For several newer kinds of prime movers began to appear, which were more efficient and useful, and it was generally thought that they were destined quickly to supplant the older source of mechanical power. It certainly does seem a roundabout and cumbersome method of obtaining work from fuel, to apply heat indirectly to turn water into steam. And it is quite possible that the vast stores of oil and coal that constitute the larger part of the world's fuel will be used in a direct way in gas-engines and oil-engines. But possibilities are not probabilities. In our opinion, some form of steam-engine will probably remain for many years the most widely useful of prime movers.

Its very defects are really a hopeful factor in the problem of its future development. If the steam-engine were now practically perfect, it would be doomed; but as it is very imperfect there is large scope for inventive engineers to increase its efficiency. We are indeed strongly inclined to think that the invention necessary to raise the steam-engine to a position of supremacy over some of its younger rivals has already been achieved. And we are happy to ... [illegible]

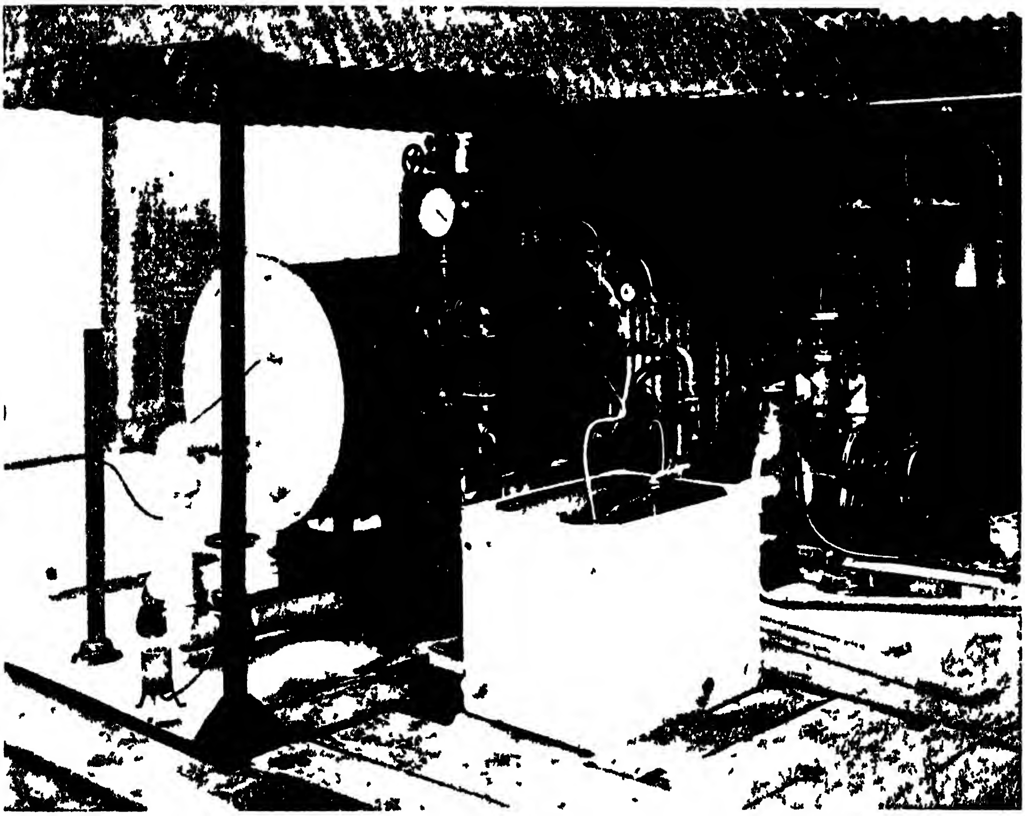
...ITION IN THE PRODUCTION OF STEAM-POWER—WATER BOILED WITHOUT FLAMES



This picture-diagram of the Bonecourt boiler shows how a mixture of gas and air is caused to burn without flame in contact with a granular incandescent solid within tubes passing through the water, thus concentrating heat just where it is required and ensuring a high degree of efficiency

that this has been done at the University of Leeds. The steam engine is so entirely a monument of the inventive genius of the English-speaking British race that it is cheering to find that we still produce the men who do most to increase its efficiency.

As we have already explained at length in POPULAR SCIENCE, Sir Charles Parsons some years ago obtained new power out of steam by means of a novel kind of turbine. But more important even than the way steam is used and set to work is the problem of generating steam from water without serious loss of the heat-energy of the fuel employed.



THE BONECOURT BOILER AT WORK AT OLYMPIA IN THE AUTUMN OF 191[illegible]

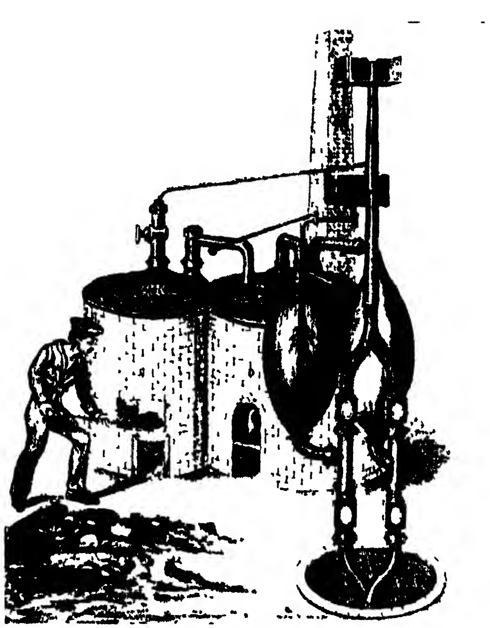
On March 30, 1911, Professor W. A. Bone announced that he and Mr. C. D. McCourt, a fellow-worker at Leeds University, had discovered a means of making gas burn without a flame. Practically all the energy usually wasted in flame was concentrated into heat under the new method.

One method of doing this, which has a very important bearing upon the future development of the steam engine, was to inject a jet of gas and air into a bed of porous pipeclay surrounding the body to be heated. It was quite easy to obtain a degree of heat twenty times more powerful than the fire required to boil water. Indeed the chief difficulty of the inventors was to find a material capable of withstanding the extraordinarily high temperatures. In many cases fuel costs were practically halved by the new method. The experiments which Professor W. A. Bone and Mr. McCourt have been engaged on for many years have now resulted in the invention of a new principle of boiler construction. By means of it ninety-five out of every hundred units of heat employed in the generation of steam are converted into steam power. In other words, the boiler has an efficiency of 95 per cent.

Small pieces of the special fireclay are placed in steel tubes situated inside the boiler. Surrounding the tubes is the water from which steam is to be generated. A jet of gas—coal-gas, water-gas, or the poorer kind of gas obtained from an ordinary producer—is mixed with air and set alight in the tubes. Attached to the gas and air pipes is a little open-air brazier filled with a few bits of fireclay and lighted. From the way in which the brazier burns the attendant can tell what kind of heat is being produced in the tubes. If more air is required, flames will appear in the brazier.

so more air is admitted through the air-pipe; and, if necessary, the pressure of both gas and air is regulated by adjusting a blower, until the proper flameless heat is seen on the surface of the fireclay in the brazier. It is thus known that a perfect combustion is being obtained in the steel tubes hidden in the boiler.

The small "Bonecourt" boiler, which, as we write, is attracting an extraordinary amount of attention at the Engineering Exhibition at Olympia, is only about three feet in length and two feet in breadth. It contains merely ten small tubes, filled with pieces of fireclay; and the mixture of gas and air is completely burnt in the first four inches of tube. Yet the steam generated is sufficient to provide power for driving the machinery of several exhibiting firms. So intense is the heat that the evaporation of water in the boiler takes place with great rapidity, and the "scale" troubles met with in other tubular boilers are completely avoided. For the scale is automatically shed in thin films as quickly as it is formed. So less pure water can be used than is ordinarily the case.


SAVERY'S STEAM-ENGINE FOR RAISING WATER

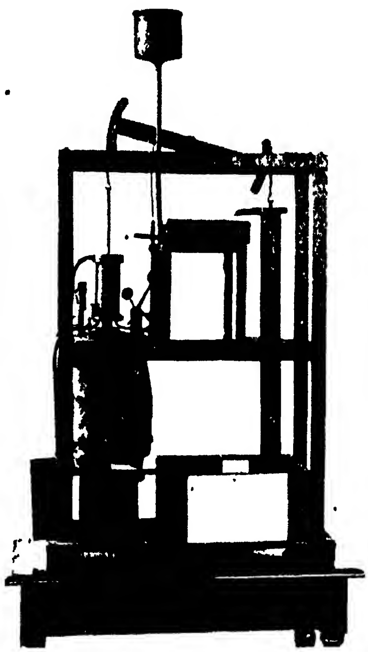
The Bonecourt boiler not only gives the steam-engine a remarkable efficiency in the use of gas heat, but it also looks very much like enabling the older form of prime mover to triumph over all kinds of petrol and oil engines. For it is found that vapourised cheap crude oil, used on the fireclay bed, produces as great a heat as a jet of gas and air. For many years steam-engineers have been trying to construct a practical form of internal combustion steam-engine. Instead of putting a kettle on the fire, they have tried to put the fire inside the water in the kettle. Their aim was to get a steam-engine which should surpass the petrol-engine and crude oil or paraffin engine in economy of working. They wanted to design a small and very powerful prime mover, using steam, which should drive a motor vehicle better than a petrol-engine now does. This seemed a few years ago an impossible task, but it has practically been accomplished.

In one of the latest steam-engines there is practically no boiler, although the affair is called a "flash-boiler" engine. The water is injected in the form of spray on to a hot surface. There it instantly flashes into steam of a very high pressure—one thousand pounds to the square inch. With this great power produced in a small space, the new type of steam-engine is remarkably efficient. And, in the opinion of many engineers of wide experience, the flash-boiler steam-engine is destined to drive all the motor-vehicles of the future. It has the high advantage of starting readily and reversing easily. By means of it, moreover, the pace of the vehicle can be regulated from full speed down to a crawl, without the need for any complicated gearing. The speed is regulated by simply varying the amount of water injected into the boiler at each stroke. Vapourised oil injected into the fireproof screen discovered by Professor Bone and Mr. McCourt may prove an admirable fuel for engines of this sort. A much cheaper oil than petrol will be sufficient to produce a terrific heat; and it is quite possible that railway locomotives, as well as all forms of motor traction, will be propelled economically, swiftly, and handily by the new steam-engine.

As is well known, great difficulty has been experienced in experimenting with explosive petrol-engines in railway work. In most cases it has been found necessary to transform the mechanical energy of the petrol-engine into electrical power, by means of a dynamo. For it is impossible to control the energy of the explosions in the way that steam power can always be controlled. And, but for the expense of electrifying our old railway systems, the petrol-engine would scarcely have come even into experimental use. So the new type of steam-engine combining all the advantages of the petrol prime mover, with the readiness and

simplicity of control of the ordinary locomotive engine, is likely now to triumph on both the railway and the road. And it is probable that it will sail the seas, and make some attempt to scale the clouds.

In what way the "Bonecourt" increase of the heat power of coal gas will affect the construction of the large stationary steam-engine, it is idle at present to speculate. Perhaps some contrivance for extracting gas out of coal will be a necessary part of large stationary steam-engines, just as a gas producer has become a vital adjunct to the most efficient kind of gas-engine. But a well-known gas-engineer has recently pointed out that, if all the gas authorities were to work together, it would be easy to give a uniform supply of gas all over England at the uniform rate of eighteen pence a thousand feet. If this were done, many manufacturers might be able to run a flameless heat steam-engine from the general gas supply, and save themselves the cost and trouble of producing their own gas. But in districts where oil is cheap this might be found to be the handiest kind of fuel, and it is highly probable that oil would be handier than coal for heating marine steam-engines of the new type. Whether this new type of engine will have a flash-boiler or a Bonecourt boiler, or whether some better way of making use on a large scale of the high temperatures of flameless heat will be discovered, is a matter that achievement will alone decide. All that can be said is that a new and wide field for the steam-engineer with inventive genius has suddenly been opened. Altogether, the battle between the steam-engine, the gas-engine, and the oil-engine has now entered upon an exceedingly interesting phase.



THE MODEL OF NEWCOMEN'S ENGINE THAT INSPIRED JAMES WATT'S INVENTIONS

(Hu[illegible] Mus[illegible] [illegible]sgow)

Of course, no final victory of any of the contesting sources of mechanical power can be foreseen. As things stand, steam has a good chance of recovering some of the ground it has lost, and, moreover, the men who are fighting its battles form the most numerous, the most experienced, and, on the whole, the most skilled class of engine-designers and engine-makers. And now that, after a period of comparative defeat, they are emerging in various directions upon a new industrial battlefield where they are winning a position of vantage, they have a boldness and an enterprise which were wanting in them in the days when they had no rivals.

Steam power is, in fact, beginning to be used in a large and scientific way. Workshop practice is combined with the free range of inventive ability in a manner that is without precedence in our engineering industry. Hitherto we have been inclined to rely somewhat unduly upon practical experience, leaving the scientific and theoretical problems of steam power to the consideration of Frenchmen in particular. But the success with which foreign engineers have worked out several of the master patents of other prime movers is beginning to affect the point of view of our own engineers. And the way in which Sir Charles Parsons discovered the steam turbine that bears his name, by going back to first principles and experimenting in a new direction, has also had a profound influence on the general frame of mind. So it comes that a fairly wide-spread movement of new ideas and new aims in steam-engine design is taking place in our country. The affair is at present one of promise rather than of triumphant achievement, though much has already been done in inventing steam-engines of remarkable efficiency. And with our fine traditions and experience, and the new spirit of inventive enterprise, it is, we think, very likely that our engineers will succeed in maintaining much of the advantage that the second Marquis of Worcester and James Watt won for them in the old days.

It was at Vauxhall in London, in 1663, that fuel was first utilised as a practical means of

performing mechanical work. For the first steam-engine was there built for raising water by Edward Somerset, second Marquis of Worcester, who was granted by Act of Parliament in the same year the benefits of his "water-commanding engine." As a matter of fact, the ingenious English nobleman invented his engine in 1655, in which year he wrote a description of it in his "Century of Inventions." But it was not until the troubled affairs of the nation were settled by the death of Cromwell and the return of the Stuarts that the engine was actually erected at Vauxhall. It consisted of a high-pressure boiler communicating with two pumping vessels. Steam from the boiler was conveyed to two vessels, and there rapidly condensed. The result of the condensation of the steam was that a vacuum was formed, and into this vacuum the water which it was desired to pump was raised by atmospheric pressure. The next dischaige of steam pressed the water out of the vessel. The piston was merely a loose wooden float, that helped to reduce the steam consumption arising from the direct contact of steam with the water to be lifted.

A PUMPING-ENGINE OF 1[illegible]7, BUILT BY JAMES WATT
This engine [illegible]s working in the last century, and is reproduced by courtesy of the Birmingham Canal Navigations.

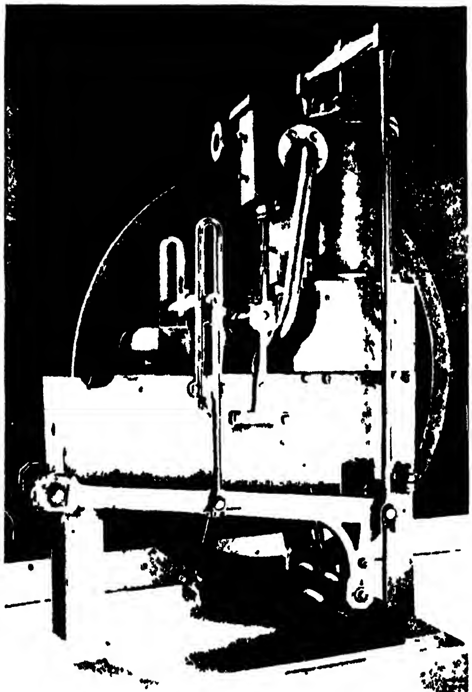
To us who know that steam power is at times equal to the explosive energy of gunpowder, it will seem extraordinary that, for a hundred years and more, steam was merely used for the purpose of creating a vacuum. But the fact is that our early inventors were more intent upon getting work out of the air that we breathe than in making use of the real power of steam. In 1654 Otto von Guericke, the Burgomaster of Magdeburg, succeeded in actually weighing the atmosphere of our earth, thus confirming the experiments made with the barometer. And when it became generally known that the atmosphere was a fluid possessed of weight that could be made to do mechanical work when a vacuum was formed, the attention of several inventors was directed to the problem of getting a vacuum quickly and easily, and then letting the weight of the atmosphere do the work required. Several years after Lord Worcester succeeded in accomplishing this, the famous Dutch man of science Huyghens invented a vacuum-engine, in which the vacuum was made by the drastic method of exploding a charge of gunpowder in the bottom of an upright cylinder.

Then another English inventor, Captain Thomas Savery, was inspired by an accident to take up the work that Lord Worcester had left uncompleted. Savery, according to his own story, was at a tavern enjoying a flask of Florence wine. Throwing the empty flask on the fire, he perceived that the few drops of wine left in it were converted into steam. Struck by an idea, he snatched the flask from the flames, and plunged its neck into a basin of water, when, by the pressure of the atmosphere, the water was quickly driven into the inverted bottle. Some writers, however, alleged that Savery merely stole Lord Worcester's idea, and purchased every copy of the "Century of Inventions" he could obtain, and burnt them in order to prevent anybody tracing the origin of the Savery steam-engine.

However this may be, Savery certainly helped to advance the use of steam, especially in the work of pumping water out of mines. Two hundred years ago England was actually faced with that exhaustion of her coal supplies which some of the most famous of our modern men of science foretell will happen in the next few hundred years. Our ancestors had excavated every known mine of coal, as deep as it could be worked in an ordinary way. The mines had become wells, into which the water drained from the surrounding land. The miners thus had no means of going on with their work, and it was under the stimulus of this grave difficulty that the steam-engine was rapidly developed into a pumping

instrument. The engine of Lord Worcester and Captain Savery was scarcely powerful enough, though by a strange chance it has been improved by Mr. C. H. Hall, and made automatic in action, and so transformed into the well-known pulsometer steam-pump.

The steam-engine that saved British coal mines from disaster was invented about the year 1712 by Thomas Newcomen, of Dartmouth. In it were first embodied on a practical scale some of the leading features of the modern steam-engine. By using a piston, for instance, Newcomen was able to force water to any height, without using steam higher than atmospheric pressure. A great rocking beam had one end attached by chains to the rods of a pump, and the other end connected by chains to the rod of a piston working in a steam cylinder. The cylinder was placed on the top of a boiler; and when a valve was opened, the steam entered and filled the cylinder. A jet of water was admitted from an overhead tank, and it condensed the steam and left a partial vacuum. The top of the cylinder was unclosed so that the upper side of the piston was exposed to the air. When a vacuum was formed beneath by the condensation of the steam, the pressure of the atmosphere forced down the piston, with the result that the end of the beam connected with the piston-rod was also made to descend. Consequently the other end of the beam rose up and worked the pump attached to it. Steam was then again admitted for the next up-stroke, and the hot water at the bottom of the cylinder was discharged by a valve.



THE ENGINE THAT PROPELLED THE "COMET," AN EARLY STEAMBOAT

At first the valves of the engine were worked by hand. Indeed, one of them is so worked in a Newcomen engine that remains in use at the present day. But it is said that a boy, who was engaged to pull the rope and open the chief valve, had the ingenious idea of attaching the rope to the beam in such a way that the movement of the beam did all the work, leaving the boy free to play. When his trick was discovered the engine was altered, and a proper mechanism for opening the valves was attached to the oscillating beam.

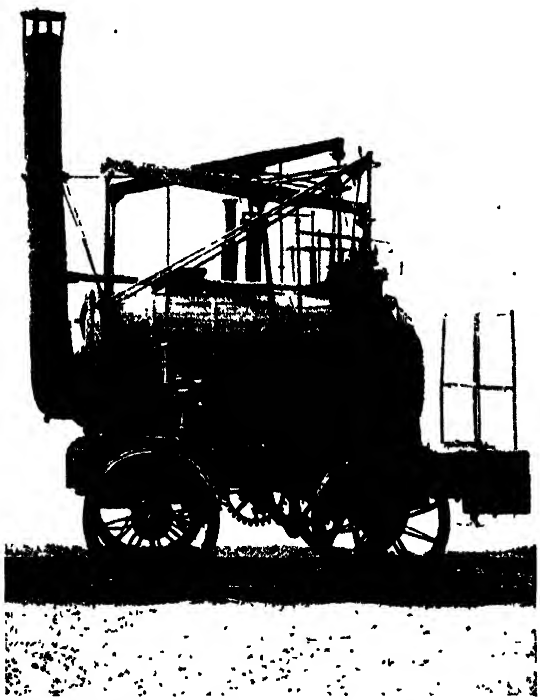
When James Watt, a scientific instrument maker of Glasgow, was asked to do some repairs to a model of a Newcomen steam-engine, he was struck with the waste that occurred in the cylinder. Every time the cold water jet was sent into the cylinder to condense the steam and form the vacuum, the cylinder naturally became chilled. So when, just before the next downward working stroke, steam was again admitted, it had first to waste a good deal of its heat in re-warming the cylinder. The result was a good deal of it was condensed in the carrying out of this preliminary operation, and more steam had to be admitted to perform the main work of producing a vacuum. So Watt devised a separate vessel for condensing the steam and forming the vacuum; and he kept the cylinder very warm by surrounding it with a hollow metal case, into which steam was admitted. By this invention in 1765, of a separate condenser, Watt at once halved the fuel consumption of the engine.

Then came the grand idea which enabled him entirely to transform Newcomen's prime mover, and design an engine on a new principle. Instead of leaving the cylinder open at the top, so that the mere weight of the atmosphere would force the piston down into the vacuum, he covered in the top of the cylinder, to exclude the cooling atmosphere of the air, and used the actual pressure of the steam from the boiler to work the piston. Thus was effected an entire revolution in the principle of the steam-engine, which then became the master force of modern civilisation.

Watt secured the patents for his single-acting beam pumping action in 1769. But he still went on with his experiments and measurements of the temperature, pressure, and volume of steam. And in the same

year in which he obtained his master patent he made another discovery which added greatly the power of his machine. He had begun by using the pressure that is stored up in steam when it is confined in a closed vessel. When water is suddenly changed into steam it increases its volume sixteen hundred times. This only happens if it is free to expand. When it is enclosed in a boiler it cannot, of course, do so, but its effort to spread out in a mighty volume of gas produces a great pressure. So great, indeed, is the pressure that if it continued unchecked it would burst the strongest boiler that could be constructed. For instance, a plain cylindrical boiler, carrying a hundred pounds pressure to the square inch, contains sufficient stored energy to project it into the air for a vertical distance of three and a half miles. A cubic foot of boiling water, under a pressure of about sixty pounds to the square inch, has the same energy as one pound of gunpowder.

A good deal of this power of steam is pressure force, and it was only the pressure of steam that Watt first used in his first engine. Just by its rush from the boiler along the steam-pipe into the cylinder it drove the piston forward. It acted somewhat as a strong jet of water might do in similar circumstances. James Watt, however, discovered that this was a very wasteful way of getting work done. He found out that steam had another working property besides the pressure it exerted. It was a gas ready to expand, as soon as there was room for it to do so. So in a very ingenious experiment he let the steam, by its mere pressure in the cylinder, drive the piston one-fourth of its stroke. He then shut off the steam, so that no more could come from the boiler. And the rest of the stroke--being three-fourths of the whole distance was performed solely by the expansive action of the steam.



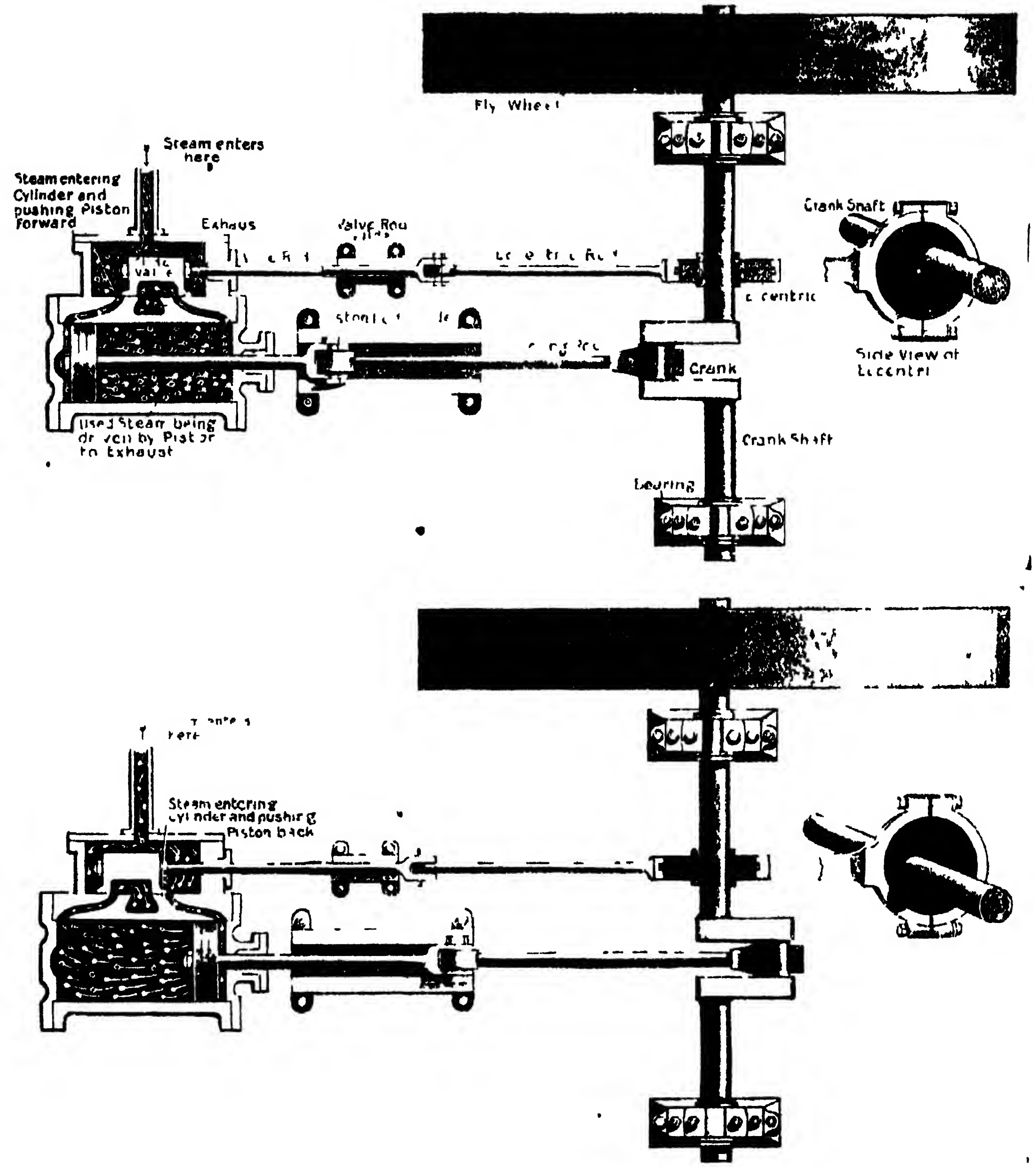
STEAM POWER APPLIED TO THE EARLY LOCOMOTIVE, PUFFING BILLY

There was some loss of power in cutting off the steam in this manner, but the saving in the steam and in the consumption of coal more than compensated for it. When, for instance, steam is cut off when one-half only of the stroke has been made, and the rest of the work is done by the expansion of the gas, the loss of power will be less than a quarter, while the saving in steam will be one-half. So Watt's new discovery enabled him to make his steam-engine much more efficient than it at first had been.

His next improvement was to make it double acting. Instead of admitting steam through one valve in the cylinder and so giving the piston a single push, he put steam-valves at both the top and the bottom of the cylinder. In this way he obtained a continual up-and-down movement, each movement being one of power. It is now usually called a reciprocating movement, and steam-engines possessing it are termed reciprocating engines. Engines in which steam is admitted at only one end of the cylinder, so as to give merely a single stroke of power in the old-fashioned way, are called single acting engines.

After inventing the double-acting or reciprocating engine, Watt set to work to devise a mechanism for converting the straight thrust and pull of the rod attached to the piston into a circular movement. This was the only thing needed to transform the pumping-engine into a universal source of power that could be used for driving the machinery in mills and factories and propelling vehicles. But here Watt suffered from the treachery of one of his workmen. He worked out the details of the mechanism, but one of his workmen revealed the idea to another man, who patented it. Instead of contesting the patent, Watt designed four or five other contrivances, and he used the best of them

in his new engines. None of them, however, was as good as the idea that had been stolen from him, and the consequence was that the development of the steam-engine was seriously delayed until the patents of both Watt and his rival had run out. the modern steam-engine is based. He invented, in 1785, the slide valve, and some years afterwards he designed the wonderful mechanism that is still generally employed in moving these valves of steam-engines. Even persons who are not familiar with the



THE PRINCIPLE OF THE SIMPLE STEAM-ENGINE: HOW THE PISTON IS DRIVEN TO AND FRO

The upper diagram shows steam entering the left port [illegible] forward the piston, the used steam passing through the right port into the exhaust chamber under the sliding valve. The lower diagram shows the [illegible] of the backward stroke of the piston. [illegible] revolution of the shaft turns an eccentric which works the sliding valve to and fro, [illegible] in turn the ports that admit and release [illegible] from the cylinder. The sliding valve [illegible]

In the meantime one of Watt's assistants, William Murdoch, famous for the part he played elsewhere in distilling gas from coal and using it for lighting purposes, effected the last fundamental invention on which hidden automatic machinery that is, so to speak, the intellect of a steam-engine must sometimes wonder at the extraordinary precision and regularity with which the enormous power of steam is controlled.

In the early primitive engine of Captain Savery each plug that worked the valves had to be turned in correct order about four times a minute by an attendant. Then, as we have related, a lad who was engaged to pull open the valve of one of Newcomen's power pumps fixed his rope on the oscillating beam, and thus solved the difficulty that perplexed all the engineers of his day. His ingenious device was developed into a rod that acted on levers which lifted and lowered the various valves. Watt adopted this device in his engine, until Murdoch designed and then improved, after years of study, the long D valve which is still in almost universal use for all but the largest engines.

GLOWING STEEL SHAPED BY A STEAM HAMMER

On the cylinder of the modern steam-engine is fitted a chest of cast-iron or stronger material. It is the steam-chest, to which steam is conveyed from the boiler. Inside the chest are three holes, and over these holes slides a thing like an oblong iron box, open at the bottom and extending over two of the three holes. This oblong box is the famous slide valve It is shot to and fro over the holes, by means of a peculiar rod called an eccentric rod, which is attached to the main shaft and moved by it. This was also Murdoch's invention. The effect of it is to take back some of the energy communicated by the piston to the revolving shaft, and use this borrowed energy in directing the steam into the cylinder, and then allowing the steam to escape after it has done its work. The arrangement is one that is more easily made clear by a pictorial diagram than by a verbal explanation.

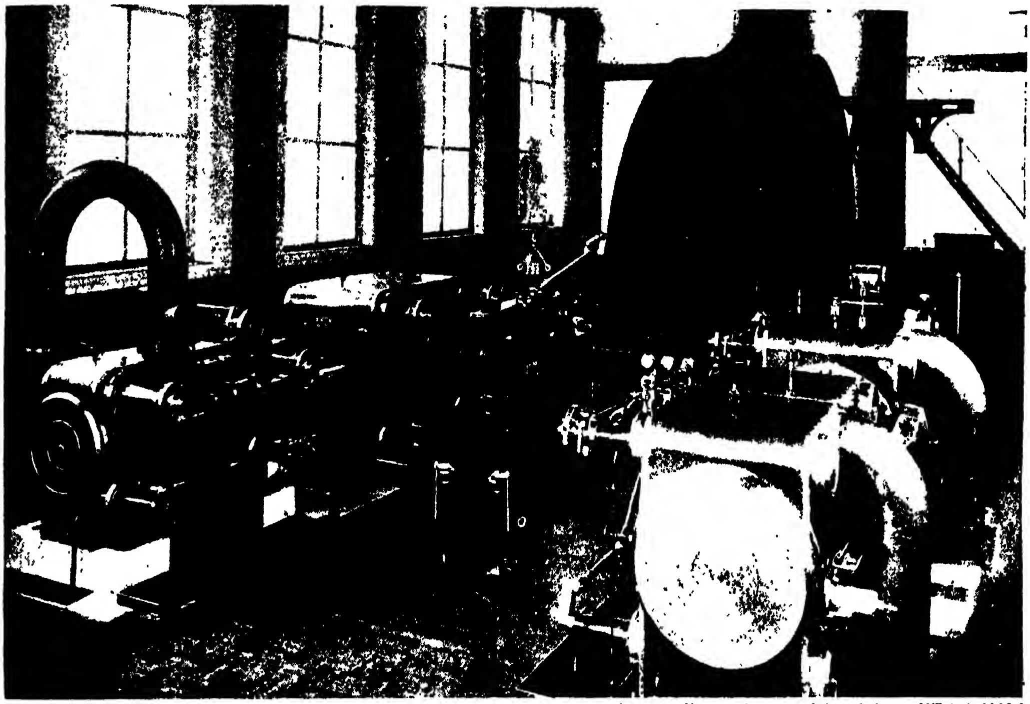
But we will attempt to describe it. We have said that the valve slides over three holes. The middle hole is called the exhaust port; the two outer holes are called steam-ports. Part of the slide valve always covers the exhaust port, boxing it off from the steam-chest, and leaving the exhausted steam only one way of escape—down the pipe to the condenser. Moreover, the slide valve is of such a length that when it slides from one steam-port, thus allowing the steam in the steam-chest to enter the cylinder, it covers the other steam-port, and so forms a communication between this port and the exhaust port. As, for instance, the piston moves under the force of new steam coming from the uncovered steam-port to the right, it drives the old exhausted steam to the left-hand port, covered by the sliding valve. So the exhausted steam passess through the inside of the valve; from there it goes into the exhaust port, and thence to the condenser.

In the ordinary way, the piston would come thud against the left side of the cylinder. But this damaging shock is prevented by so arranging the movement and construction of the slide valve that, just as the piston is finishing its stroke, the left-hand steam-port begins to uncover. Getting partly clear of the valve, it admits a little steam that "cushions" the finishing stroke of the piston. Then, as the port becomes more uncovered as the sliding valve travels away from it, the full amount of steam enters the cylinder, and impels the piston forward in a movement of power. By this time the right-hand steam-port has been covered by the slide valve, and its exhausted steam is pushed by the travelling piston into the interior of the valve, and from there into the exhaust port and the condenser. The whole operation seems complicated in a description, but it is wonderfully easy and swift in actual working. And it was when its mechanism was completely developed by Murdoch, in 1800, that the modern steam-engine was, in all its fundamental devices, fully born.

To regulate the speed of his rotative engine, Watt merely adapted a large instrument, termed a governor, which was already in use in windmills and watermills. It consisted of an upright spindle, carrying two hanging arms provided at the lower ends with heavy metal balls. The spindle revolved by means of power transmitted from the engine. So, when the speed of the engine was very high, the spindle went round at such a rate that, by its centrifugal force, it shot out its two arms carrying the heavy metal balls. By an arrangement of levers, this movement of the swinging arms was transmitted to a valve in the steam-pipe, and the valve throttled the supply of steam, and so diminished the speed of the engine.

It was a rough and wasteful way of governing, but for the time it served its purpose. In addition to the governor, Watt had also to design a mechanism for taking up the sudden and swift spurts of power of the backward and forward movement of the piston-rod. For even when this thrusting movement was transformed into the circular motion of a revolving shaft, and regulated by a governor, there were times when the whole machinery was inclined to run unsteadily. By the simple expedient of fixing a large, heavy fly-wheel on the spinning shaft, Watt obtained a reservoir of energy that stored up all variations in the power of the engine and distributed it in a steadying and equalising way. Anything that is spinning round tends to maintain a regular speed, and resists any attempt to decrease or diminish it.

So the fly-wheel of an engine helps to prevent any sudden variations in the output of power, and enables different kinds of work to be done in a smooth and regular manner. At the present day, enormous fly-wheels are often used as reservoirs of energy in steel-rolling mills. An engine, incapable of suddenly supplying the enormous power required to move the rollers that press a ten-ton block of steel into a plate, is first set running light. It drives its great fly-wheel up to a high speed, and then the ingot is placed between the rollers. As the engine slows down and fails, the immense force stored up in the momentum of the wheel comes into play and assists it, so that the rolling is done.



A FOUR-CYLINDER TRIPLE-EXPANSION STEAM-ENGINE THAT DRIVES E PLANT OF A COTTON-MILL
From a photograph by courtesy of Galloway's, Ltd.

A difference between Newcomen's engine and the steam-engine of Watt, as developed in 1800, is strikingly shown in the respective amounts of work the two machines accomplish. For every 112 pounds of coal consumed, Newcomen's engine, in 1718, pumped 4,300,000 pounds of water to a height of one foot. With the same amount of fuel, Watt's engine raised to the height of

one foot 66,000,000 pounds of water. Thus it was about sixteen times more efficient.

Great genius, however, as Watt was, he had the defects of his qualities. As long as he held most of the master patents of the steam-engine, he opposed the introduction of some improvements of very high importance. So it was not until his patents expired, in 1800, that the power of the steam-engine began to be rapidly developed by other inventors.

Some Misconceptions and Obstinate Mistakes of a Great Inventor

One of the most valuable of the new ideas was the use of steam under a high pressure a thing to which Watt had been vehemently opposed. In his engines, the steam that entered the cylinder from the boiler was only at the pressure of the atmosphere, which is little more than 14½ pounds to the square inch. The work of steam of this force was practically finished when it left the exhaust port of the cylinder. But when later inventors confined the steam in a boiler and subjected it to greater heat, its pressure was enormously increased. Finer and stronger workmanship was necessary in making boilers and cylinders to withstand the terrific strain. Indeed, all the main working parts of the engine had to be strengthened and constructed with more exactitude.

The consequence was that the later development of the steam-engine was closely related to the progress made in workmanship, machine tools, and iron and steel production. Watt once congratulated himself on the fact that one of his steam cylinders was only three-eighths of an inch out of truth in the bore. Nowadays, a good engine-builder would reject a cylinder that was one-five-hundredth of an inch out of truth; while in small petrol-engines the greatest limit of error often allowed is one-five-thousandth of an inch.

Improvements for Extracting from Steam All the Power it Carries

As materials and workmanship improved, the engineers were able to increase the pressure of steam that entered the cylinder and impelled the piston. When this work was done, there was still a good deal of power left in the steam. So, instead of allowing it to escape into the condenser, it was discharged into another cylinder, and made to move another piston. In this way a single spurt of steam from a boiler was sometimes passed through five cylinders, and made to move five pistons before it escaped through the final exhaust port. Engines in which steam is made to do from double to fivefold the work of moving a single piston in a single cylinder are called compound engines. Each cylinder is larger than the one before it, for the reason that the steam expands and falls in pressure after performing each of its tasks. It also tends to grow colder and condense into water in its long and intricate journey, and it injures the pipes and vessels through which it passes. But these difficulties are now, however, largely avoided by means of a superheater.

The apparatus usually consists of a nest of tubes placed in the fire-box close to the boiler, but sometimes the tubes are heated by a fire of their own away from the boiler. The steam passes through the tubes, which are often economically heated by diverting, on their way to the chimney, the hot gases from the coal in the furnace. As soon as ordinary steam comes into contact with a surface cooler than itself, such as the pipes of the cylinder of the engine, it begins to condense and rapidly loses force. But if it has been superheated, it has a considerable amount of heat with which it can part before condensation begins. Over 10 per cent. of steam is now commonly saved by the use of superheaters.

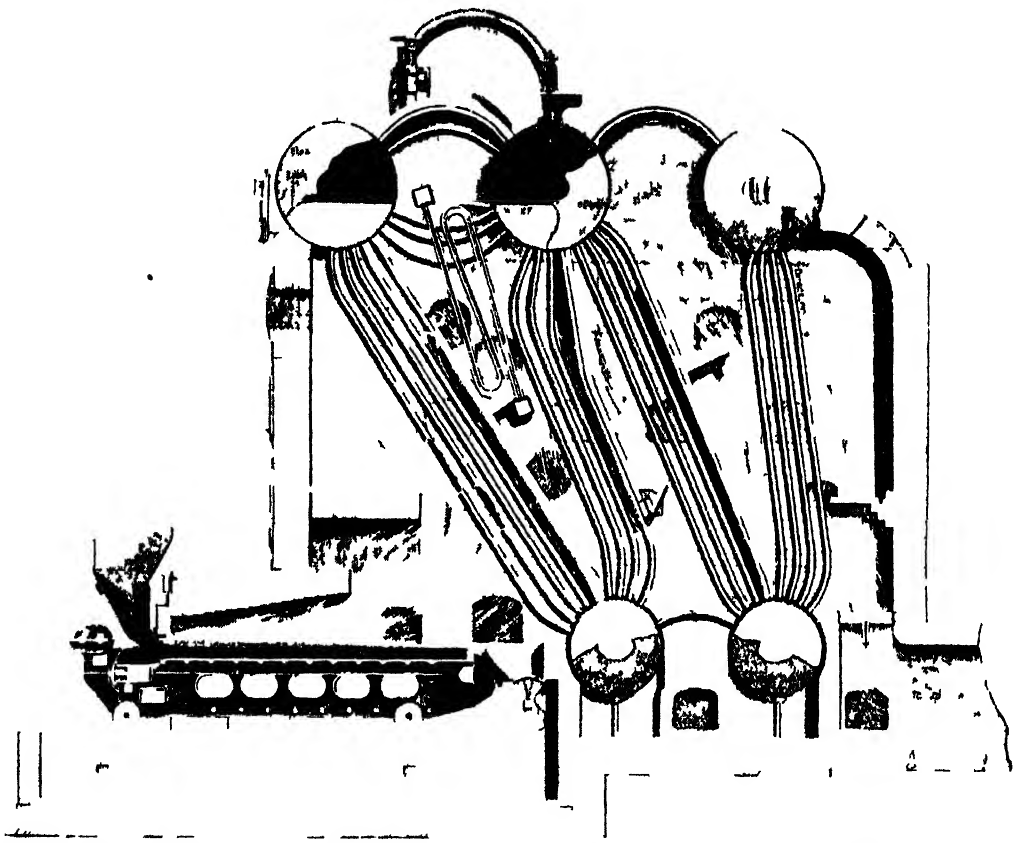
Progressive Devices for Retaining All Heat as Long as Possible

This takes place in compound engines that were originally designed with the utmost economy in working. In more ordinary types of engines the saving is much greater. Practically the whole trouble of the steam-engine designer is to save heat losses. His first aim is to get the greatest amount of heat possible out of the coal. So he never allows the fumes to go straight up the chimney, but circulates them round and round the boiler and sends them into a superheater. But the consequence is that they are sometimes insufficient, when they emerge from the chimney, to create the draught necessary in the furnace. Rather, however, than let the burnt gases swiftly escape, and use up some of their wasting heat in providing the necessary draught, the modern engineer prefers, if possible, to take a little power from his engine, and employ it to work a fan producing a mechanical draught. This is one of the reasons why chimneys for steam plants are much less tall than they used to be. The old-fashioned tall chimneys were not built at great cost to prevent the fumes from the fire from contaminating the air, but to

create a strong draught in the furnace. So where mechanical draught is employed a chimney can be one eighth to one fourth as tall as an old fashioned structure. Less than one hundredth part of the heat that is saved is sufficient to work the fan.

Moreover, the engine is rendered independent of wind and weather. Inferior fuels can be completely and quickly consumed, and at times of uncommon demand a fire can easily be forced so as to augment the steam production of the boilers. In the best modern practice the feed water for the boilers is heated by the furnace gases just before they enter the stack, and the piping for this purpose is formed into coils known as economisers, which check the chimney draught. This checking is readily overcome by the mechanical draught, leaving the engineer considerable net gain as fan and economiser are united. One incidental advantage in modern steam engine plants of sound design and good management is that they send forth little or no smoke. Smoke is a harmful, unnecessary and expensive waste; with thorough combustion none of it leaves the chimney.

Yet when all is done with economisers, superheaters and the best of modern boilers, the amount of heat which is put to a useful purpose in a steam engine is only about a quarter of that given out by the coal. The other three quarters goes up the chimney. Moreover, a good deal of the heat that is imparted to the boiling water and carried along by the steam in the performance of its work is lost. Some of it is wasted in radiation from the boiler and pipes, and a little over six tenths of it is rejected to the condenser. Careful and elaborate calculations show that in the ordinary steam engine under the best conditions at present obtainable a shilling's worth of coal has to be burnt to capture the energy stored in a pennyworth. This is what makes the 95 per cent efficiency of the Bonecourt boiler so extraordinarily important an advance in steam engine construction.



A DIAGRAM SHOWING HOW STEAM IS GENERATED AND SUPERHEATED IN A MODERN BOILER
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THE PLANTATION IN THE EAST WHICH YIELDS REFRESHMENT FOR THE TABLES OF THE WEST

A GROUP OF COOLIES PLUCKING THE LEAVES FROM THE TEA-SHRUBS IN A PLANTATION IN THE ISLAND OF CEYLON

BREAKFAST BEVERAGES

How Science Enables the European Planters to Excel the Native Cultivators

THE PRODUCTION OF TEA, COFFEE & COCOA

It is not very long since the generality of our people used small beer as a breakfast beverage, milk forming the drink of children. In the days of Shakespeare tea cost from £6 to £10 a pound, and coffee and cocoa were practically unknown. It was about the middle of the seventeenth century that the three famous beverages, that cheer but not inebriate, came into use among the richer classes of European society. The London coffee-houses, in which gathered the wits, poets, and politicians of London, in the days of Dryden and Congreve, Addison and Pope, were the centres of national life for many years. And from them sprang the clubs, around which many of the social, literary, and political activities of the civilised world are now grouped.

Very likely the new beverages greatly helped to foster all kinds of sociality, for the reason that they stimulated the mind without leading to the brawls and quarrels of tavern life. And the fact that they were at first rare and expensive was no doubt one of the reasons why they became extremely fashionable. Towards the end of the seventeenth century, the duty on tea in England was 50s. a pound. So a "dish of tea" was a costlier thing than a glass of good wine. Human nature being what it is, everybody was eager to drink the new beverage. The East India Company began to send to China for parcels of tea. At first they had more of the new commodity than they could dispose of. But, as is often the case, the supply created the demand, and at the end of the eighteenth century the English-speaking races were second only to the Mongolian races in their love of tea.

But as the consumption was then only about two pounds of tea a year per head of the population, small beer and milk still remained the common beverages of the working classes. Cheap spirits, especially gin, were drunk by many poor women, with dreadful results. The writer can still remember the sad aspect of the morning crowd of female gin-drinkers, who attended as out-patients at a London hospital in which he was interested. At the present time, practically all the civilised races have abandoned the breakfast drink of more or less intoxicating liquors for one of the three exotic stimulants that modern methods of industry have greatly cheapened in price, and often improved in quality. All the British races have become inveterate tea-drinkers. The Russians have acquired the same taste; and the very heavy duty on teas does not prevent the Russian working classes from adopting the same beverage as the well-to-do classes of their country. In Germany, Holland, and other parts of Northern Europe, coffee has become the general morning stimulant; while the French and other Southern races waver between coffee and chocolate as a breakfast beverage.

This national difference in taste has had a considerable influence on the agricultural and industrial development of the tea plant, the coffee shrub, and the cacao tree. In spite of the fact that all these plants are of tropical or semi-tropical origin and habit, the European nations interested in their products have attempted for centuries to cultivate them. Here the progress of European science, and particularly the science of botany, has had a large influence; and the peoples possessing tropical colonies or dependencies have often won a commanding advantage over the original cultivators. In some cases this was an inevitable consequence of the widening demand throughout Europe for the new commodities. For instance, all the coffee consumed in Europe used to come from the province of Yemen, in Southern Arabia.

But as the number of coffee-drinkers increased, it was practically impossible for the Arabians to cope with the demand. They still retain the trade with Egypt and Turkey, and provide a little Mocha coffee for Europe. But in order to obtain a beverage that was both good and cheap, the Dutch and the Portugese and the Germans have had to migrate to Java and Brazil, and there develop immense coffee plantations for the benefit of the white races.

A similar thing has happened in regard to cocoa and chocolate. As is well known, cocoa was introduced into Europe from Mexico by the Spanish adventurers who conquered the bloodthirsty Aztecs. The cacao-tree flourishes in Central America and the tropical regions of Southern America. But the native Indians who collected the beans of the tree that Linnæus enthusiastically named "the food of the gods"—an appellation it still bears in botany—were too slow, casual, and unscientific workers. So the Portuguese introduced the valuable tree into their African possession of San Thomé, where, by means, unfortunately, of slave labour, more cocoa was lately produced than in any other centre of the industry.

FATHER AND SON CARRYING TEA IN THE WEST OF CHINA

But the most surprising of all the shiftings of the production of the breakfast-table beverages is that accomplished by the British race. For more than a thousand years the tea industry was entirely in the hands of the Chinese. The origin of their surpremacy in the production of the most refreshing of drinks is lost in the mists of their legendary ages. It is quite possible that three thousand and more years have passed since they took to cultivating the tea shrubs that flourish naturally in India, Burma, and other neighbouring lands swept by the wet monsoons. The Chinese were a skilful, patient, and ingenious race, backed by the traditions of an ancient civilisation and their knowledge of the preparation of tea was for a long time carefully kept from the foreigner, for it was one of the main sources of the national wealth.

But some of our botanists succeeded in studying the tea plant, and found it was a evergreen shrub of the same family as the camellia, that is well known for its beautiful flowers. Then it was discovered, in 1820, that the tea plant was growing wild in Assam, and the wild plant was sent to the director of Kew Gardens for examination. Unfortunately, the director would not believe in the plain evidence submitted to him; and he dashed the hopes of the men who thought of establishing tea plantations in India, by stating that the Assam shrub was not a true tea plant. It was not until 1840 that the facts of the matter were clearly and firmly proved, to the discredit of the director of Kew Gardens. The Assam Tea Company was then formed, and by developing the scientific cultivation of the fine native Indian tea it has now paid its shareholders nearly 750 per cent. on their capital.

Introduced into Ceylon after the coffee plantations of that island were destroyed by a harmful microscopic fungus, the wild tea plant of Assam has now enabled the Ceylon planters alone to excel the tea exports of the whole of the Chinese Republic. When the British directed tea industry of India, Ceylon, Burma, and the Shan States is contrasted as a whole with the export tea trade of China and Japan, the swiftly won supremacy of the British planter is seen to be tremendous. The British possessions do more than double the export tea trade of China; and for some years a good many million pounds of Indian and Ceylon tea of poor quality have been imported into China. The Japanese, who

recently controlled practically all the tea trade with the United States, are also beginning to feel very keenly the competition of the British tea planter. They are now so hard pressed that they are giving up the struggle, and the taste for fine Indian and Ceylon teas is now rapidly spreading throughout Northern America.

Only the plantations on the island of Formosa seem to be safe from the scientific attack of British botanists and planters. Formosan tea known in the market as Oolong - has a curious and special flavour which our tea-blenders prize. With the exception of Formosan tea and the maté tea of South America, India and Ceylon now produce teas of every practical variety. The choicest kind of Indian hill-grown teas are excelled by nothing that China exports, and for blends of cheap, strong, pure leaf the plantations of Ceylon are unrivalled. The Chinese themselves have had to come to India and study under an Englishman the science of the tea industry in order to learn to handle in a clean and efficient manner their own produce. The Indian tea plant has been introduced into Java, and there cultivated and handled on our methods, and Java is now combining with India and Ceylon in sending the refuse of their factories to Chinese ports.

The amazing agricultural victory which the men of our race have won against the experienced Chinese was achieved by three concurring factors. These factors were modern science, personal enterprise, and modern power machinery. Modern science, in the persons of a few British botanists, discovered the wild tea plant of Assam, and thus provided our planters with a stronger and more productive shrub than the highly cultivated plant of the Chinese. The leaf of the Assam shrub is twice the size of that the Chinese plant; and when it is grown in the still, steaming heat of Ceylon and other tropical regions, it produces two crops where the Chinese plant only gives one picking. Such are the natural advantages of the plant that our men of science discovered. The tea-planter began by adopting the Chinese methods of cultivation, for which the wild plant was unsuited. Again our botanists came to his aid, and taught him how to treat the Indian shrub in a manner that best favoured its growth.

Having thus learnt to make the very best of his natural advantages, the planter

PLANTING OUT A YOUNG TEA SEEDLING IN LAND RECLAIMED FROM THE WILD

COOLIES SORTING THE FRESHLY GATHERED LEAVES OF THE EVERGREEN TEA-SHRUB

then became a man of enterprise. He called upon the engineers of his nation to provide him with power machinery for dealing with the tea leaves that the natives picked for him. This was a very wise act, and it required some foresight to conceive it. For the supply of native hand labour grew abundant and remarkably cheap, and it would have been easy to carry out all the operations of preparing the tea leaf by means of manual work. But the British tea-planters aimed at preparing an article that should be exceptionally clean, and treated with the utmost precision in every process, so that large quantities could be regularly turned out possessing identical qualities. So they began to use machinery; and the malpractices of a large class of their rivals in China further helped them to secure the British market.

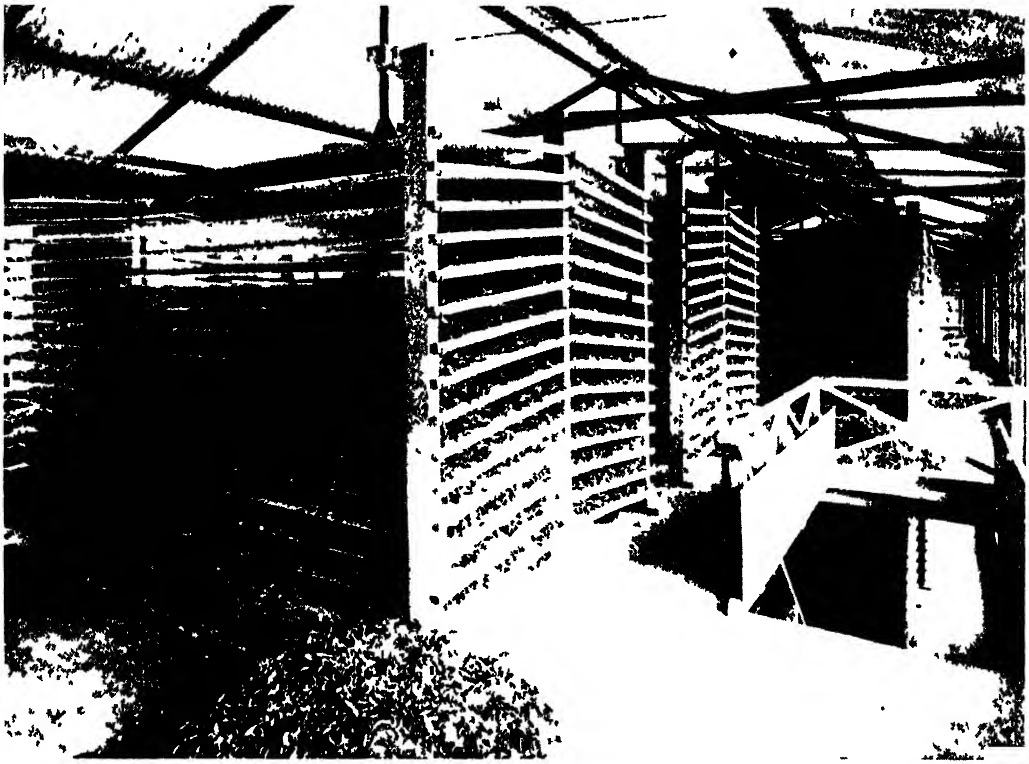
In the green-tea districts of China practically every cottager has his own little tea-garden. It supplies the wants of the family, and brings in a small but very useful amount of money. The picking begins about the middle of April. The first crop consists of scarcely expanding leaf buds, and the tea made from them is costly and exquisite. It is chiefly used in gift offerings at marriage. The plucking of the bud is liable to injure the plants, but usually the abundant spring showers renew the strength of the shrub, and in two or three weeks it is ready for the second picking. This is the most important of the season; but when the plant has again recovered, the third and last gathering is begun. This, however, produces an inferior variety of tea. The instruments used by the Chinese in preparing the tea leaf are very simple.

Quite a large proportion of the tea that comes from China is manufactured in the huts and sheds of the peasantry. Round, shallow pans of thin iron are built, several together, in a brickwork furnace. The fireplace is at one end, the rough chimney at the other, so that the flue runs beneath the row of pans. When the leaves are brought from the garden they are placed in a drying-house, which is often the cottage itself. The furnace is then lighted, and the leaves are thrown into the heated pans, and continually stirred by the cottager and his family. The heat causes the leaves to crack and exude their sap, and in about five minutes they grow soft and pliable. They are then placed upon bamboo tables, and the workers take up handfuls of the leaves, and knead them in much the same fashion as a baker works dough. The object of this process, that

COOLIES HOEING A TEA PLANTATION IN CEYLON

lasts about five minutes, is to twist the leaves and press out the sap and moisture, which escapes through the chinks in the surface of the table.

The moisture that still remains in the leaves is then got rid of very gradually and gently by taking the rolled leaves and spreading them out thinly and evenly upon a screen of bamboo, and there exposing them to the action of the air. The state of the weather determines this stage of the manufacture, but in no case is the screen exposed to hot sunshine. For this would evaporate the moisture too quickly, leaving the tea crisp and coarse, and unfit for the next process. This consists in replacing the soft and pliant leaves in the drying-pans over a slow, steady fire. The tea must not be scorched or burnt. So one worker looks carefully after the fire, while the others bend over the pans and begin to mix and stir the leaves with their hands. As the heat increases, small bamboo whisks are used, the leaves being thrown against the sloping sides of the pans and allowed to roll back to the bottom. Under this treatment the tea gradually parts with its moisture, and twists and curls, and after about an hour it is taken from the pans, and sorted, and packed.



THE TIERS OF TRAYS ON WHICH THE GREEN LEAVES ARE TOUGHENED BY EXPOSURE TO AIR

This is the process of making green tea. Black teas are allowed to stand longer in the open air, usually for two or three days. During this time they undergo a fermentation which does not take place in the manufacture of green teas. In the firing or final drying of black tea, great care must be taken to keep the heat steady. Usually the grandfather of the family, having the most experience, tends to the furnace, while his descendants keep the leaves constantly stirred in the pans.

The scandal over the manufacture of Chinese teas occurred at Canton, where the green teas were mainly exported. In order to increase the colour and brilliance of the leaves they were treated with gypsum and Prussian blue, a highly poisonous product. The tea-tasters at the London market, who had to sample very large numbers of consignments of these teas, were at times liable to attacks of poisoning. These were at first put down to heavy tea-drinking, and few tasters now swallow much of the beverages they sample. But chemical analysis proved that it was the poisonous colouring matter used by the Chinese that produced the serious illnesses.

No doubt at the present day the green teas of China are generally prepared for the

foreign markets in a proper manner. But the injury to the reputation of the Chinese tea manufacturers has not yet been fully repaired. Their malpractices have greatly helped to advance the prestige of the cleanly and scientifically prepared teas of India and Ceylon. In 1885 China exported [illegible]466 pounds of tea. In 1909 she only marketed abroad 199,792,400 pounds. The export of British planters in India, Burma and Ceylon, on the other hand, is mounting up to an annual total somewhere between 400 and 500 million pounds. With a Trans-continental railway through Persia connecting with the Russian railway service and attack her, is an admirable representative of a great new industry built up by scientific methods and laborious enterprise.

There are about half a million acres of tea plantations in India, the greater part of which are in Eastern Bengal and Assam. The fine Assam teas are now so famous that the Chinese have at times attempted to extend their falling market by calling their produce Assam Pekoe Souchong. In Ceylon somewhat under four hundred thousand acres of land are planted with the tea shrub, and the value of the richly productive plantations has recently been further enhanced by interplanting them with rubber trees.

THE MACHINES THAT ROLL THE [illegible] TEA LEAVES

the British tea planter would only need a reduction in the Russian tea duties in order to extend enormously his already enormous production of the most stimulating of beverages. As we have remarked, he is conquering the markets of Northern America, and with the spread of the English fashion of afternoon tea on the European Continent, he is beginning to compete there with the coffee planters of Brazil and the cocoa planters of Africa and tropical America. Excellently organised for the promotion of his interests with a common fund of advertising for other purposes and a council for planning campaigns of defence

The average size of an estate is about three hundred acres, and though there has been a tendency of late years to group several plantations under one working staff to reduce working and maintaining expenses, a large number of estates are of comparatively small size and directed by British planters resident on the land.

Yet a good many planters are now only the servants of some company, instead of being, as they used often to be, the actual owners of the estates. An enormous labour supply of 400,000 coolies is necessary to run the Ceylon plantations. The Tamils of Southern India form the principal recruits

Entire families of men, women, and children are collected in their villages and transported to Ceylon. The majority are fairly good workers, and return home with an amount of savings that often enable them to rise in life, but some are so pleased with the good wages they earn that they settle down permanently by the tea plantations.

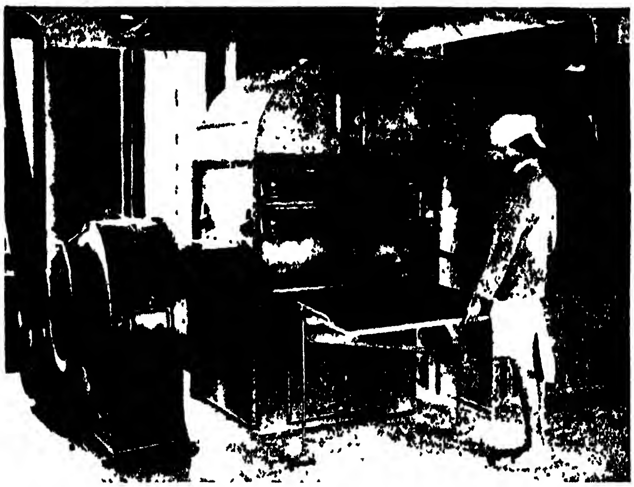
In opening out a new tea garden, the coolies begin by clearing and hoeing and trenching a pieces of the jungle. This forms a nursery. It is carefully fenced to prevent damage from cattle or wild animals, and planted with seed, which has been sprouted in seed-beds. Then it is covered with thatching to protect it from the scorching sun. In the meantime, the site of the future plantation is being cleared and hoed, and roads and drains are made through it. Stakes are then placed in the soil, about four feet apart, marking the rows in which the young tree plants are to be grown. The plants are taken from the nursery, when about a foot high, and very carefully planted in the lines of holes prepared for them. The planter has then to wait for three years for any return on the young plantation, and he has to bear a considerable running expense for the incessant labour needed to keep down the vigorous tropical weeds. He has to endure also the hot, stagnant, steaming heat of the jungle, which is so vital a necessity to the Indian tea plant that when Chinese methods of cultivating were first adopted the native shrub refused to grow properly.

When grown in accordance with their native habit, the plants at the end of three years begin to send out an abundance of young leaf shoots, known as the "flush." The plucking is then carried out at regular intervals, and from time to time the bushes are pruned. This not only keeps the growth of the plant within bounds, and allows the plucking being done easily, but it promotes the growth of abundant flushes. In the colder climate of China and Japan, the flushing ceases in the winter. In Ceylon, however, it continues throughout the year, and the flush is ready for picking every ten or twelve days. Upon the size of the leaf when picked depends the quality of the tea. In fine plucking, the bud at the top of the shoot and the two young leaves just below it are taken. In medium plucking, three leaves are taken with the bud. In coarse plucking, four leaves and the bud are gathered.

The teas known as Pekoes are made from the fine plucking. Flowery Pekoe consists of the youngest leaf, Orange Pekoe

SIFTING TEA INTO ITS VARIOUS GRADES IN A FACTORY IN CEYLON

is made from the second leaf, and Pekoe from the third leaf. From the larger leaves Souchongs and Congous are prepared, and there is also a mixture of young and old leaves which is known as Pekoe-Souchong. In purchasing tea it is best to buy one of the Pekoes, and for two reasons. The quality of the beverage made from the youngest leaves is finer and more wholesome; and, besides, a less quantity of tea is needed in the teapot. Tea from 2s. to 3s. 6d. a pound yields 280 cups to the pound; tea made from the coarser and larger leaves, selling at from 1s. to 1s. 8d. a pound, only produces 224 cups to the pound. So practically nothing is lost in paying 2s. instead of 1s. 6d. a pound for household tea; and for persons with a good palate and a regard for their digestion much is gained. All the money lavished on the advertisements of cheap, coarse teas made from large, old leaves will not alter this fact.



"FIRING" OR DRYING TEA BY EXPOSING IT TO HOT CURRENTS OF AIR

Gathered into baskets by women, and taken into the factory, the flush is weighed, and then thinly spread out on shelves of canvas or wire mesh, placed one above the other, where the leaf naturally withers in good weather in about eighteen hours. The withered leaves are then shot into the rolling-machines, where they are bruised to allow their juices to become mixed, and they are also curled or twisted. From the rolling-machine the tea falls in yellow, clinging masses into a roll breaker, that breaks up the masses and drops the tea into a sifter, where the coarser leaves are separated from the younger, finer growth.

Then comes the important process of fermentation. On its success largely depend the quality and character of the tea. As we have already explained, green tea that was formerly so popular is manufactured by omitting the fermentation process, but all black teas are fermented. This is accomplished by putting the rolled leaf in drawers or on mats, which are placed one above the other so as to permit the air freely to enter and work on the bruised leaves. During the fermentation the leaf emits a peculiar odour, and changes colour; and when the right gradation of copper-brown tint has been attained—which usually takes about two hours—the leaf is fired in the drying-machines, and all other fermentation is arrested by the heat. Besides checking the fermentation, the firing process removes all the moisture without driving off the essential oil and other constituents that give a tea most of its value.

There are many types of firing-machines. But all of them act by sending a current of hot, dry air through the damp, fermented leaf, and making it dry and brittle. After being fired the tea is taken to the sorting-room, and sifted by a machine through a series of moving sieves of varying sizes of mesh. The siftings are classed as Flowery Orange Pekoe, Orange Pekoe, and Pekoe No. 1. These are unbroken teas. But the coarser leaves, which do not shoot through the meshes, are transferred to breaking-machines, and broken up and passed through the sieves. They form the products known as Broken Orange Pekoe, Pekoe No. 2, and so on. The tea dust is shipped separately as "dust" and "fannings." The green teas are sifted in a similar manner into a descending scale of quality, represented by Young Hyson, Hyson No. 1, Hyson No. 2, Gunpowder, and Dust.

The coffee trade of our country is much inferior in importance to a tea trade. In Germany, on the other hand, it is the national breakfast beverage, and so it is in Holland. The Arabian coffee plant is a shrub that grows to a height of about fifteen feet. It has been found wild in Abyssinia, and there are good grounds for supposing that this region of Africa was the natural home of the plant. The flowers are white in colour and exquisitely

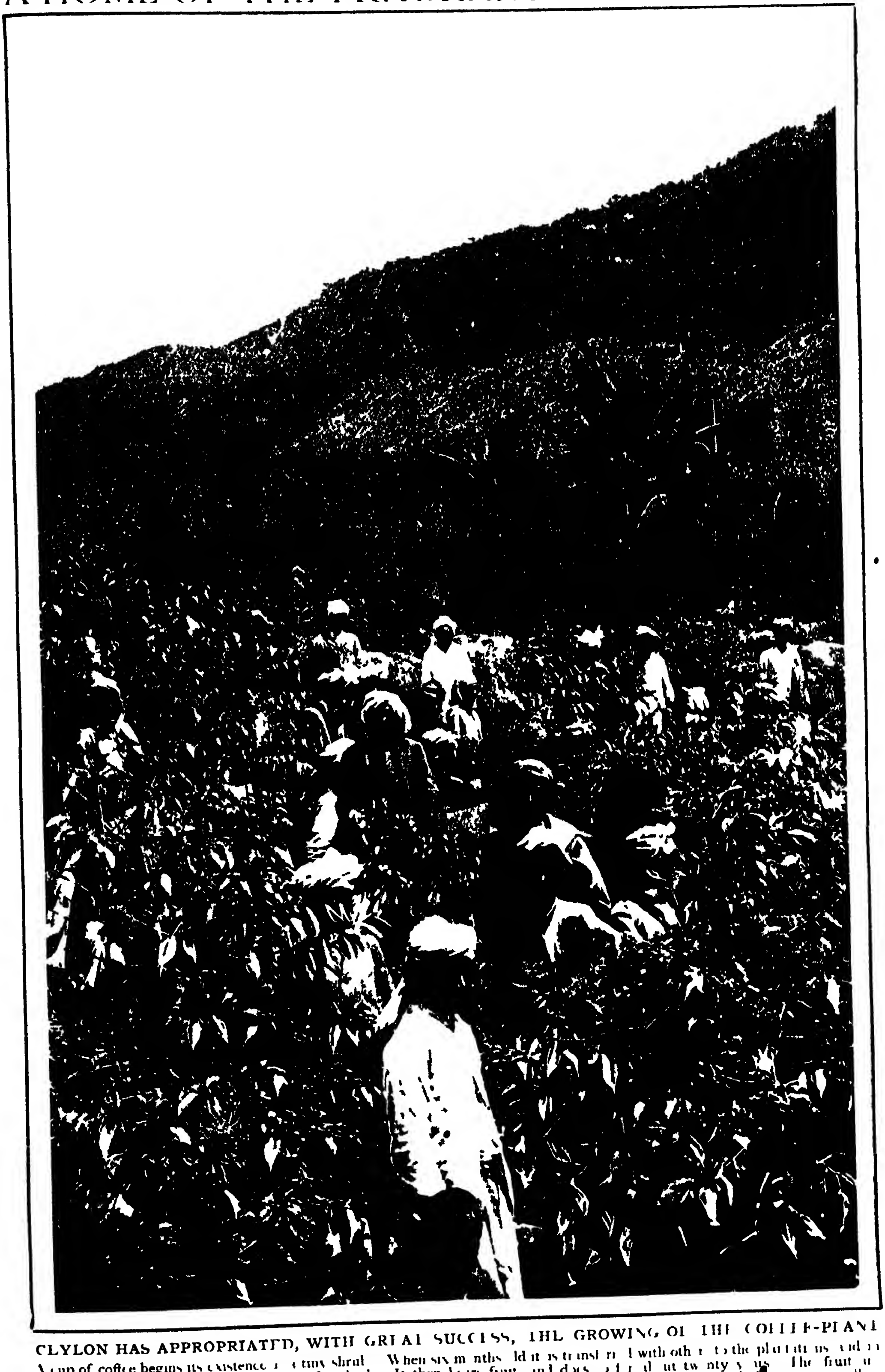
fragrant, and from them is born the coffee cherry, which, as it ripens, turns from a dark green to a deep crimson. The outer portion of the fruit somewhat resembles that of an ordinary cherry, and inside the pulp are the two beans, of a greenish-grey tint, that form the coffee of commerce. Besides the Arabian coffee plant, there are about eighty known varieties of the shrub, but only two of them are cultivated in considerable quantity. One is found on the West Coast of Africa, and is called Liberian coffee. By reason of the fact that it is more resistant to disease, and more vigorous in growth than the Arabian coffee plant, it has gradually won for itself a place in the Orient.

The third variety of coffee plant is the Maragogipe, discovered in 1870 near the town of that name in Brazil. It is very hardy, and twice as large as the Arabian plant, and its berries are double the size of the latter. It commands a very good price, and it is a special favourite in Germany, but our best judges are disinclined to allow that the quality of its infusion is in any way superior to that of the Mocha coffee berry. Experiments are still being made with the numerous other varieties in the hope of finding a kind especially fitted for cultivation in different regions. In the Botanical Gardens of Ceylon and Trinidad a Sierra Leone plant is being cultivated, and it is reported that its beans are superior in flavour to those of other coffees. More recently the Trinidad Botanic Gardens have begun to experiment with another species, which is also said to be of high value.

However this may be, the Brazilians now exercise over the coffee market a greater influence than even the British planter exercises over the tea market. They produce at least three-fourths of the beans, and with little or no effort their planters could flood the market. They refrain at present from so doing, in accordance with an agreement which was drawn up to prevent a continual over-supply from lowering the price of the produce. In the State of San Paulo, the province in Brazil where the most important plantations are established, the average yield is fifteen hundredweight of berries from a thousand trees. But by clearing new land in the jungle and planting trees there the extraordinary return of a hundred hundredweight is obtained from the same number of trees. It is this immense reserve of productive force which enables Brazil to

MODERN MACHINERY EMPLOYED IN SORTING TEA IN A FACTORY IN CEYLON

A HOME OF THE FRAGRANT COFFEE-BERRY



CEYLON HAS APPROPRIATED, WITH GREAT SUCCESS, THE GROWING OF THE COFFEE-PLANT

A cup of coffee begins its existence as a tiny shrub. When six months old it is transferred with others to the plantations, and in three years grows to between six and ten feet high. It then bears fruit, and does so for about twenty years. The fruit is something like dark red cherries, but, instead of containing one stone, there are two seeds or berries, of a light green or yellow colour. Here we see the coffee being picked.

BERRIES THAT STIMULATE THE BRAIN

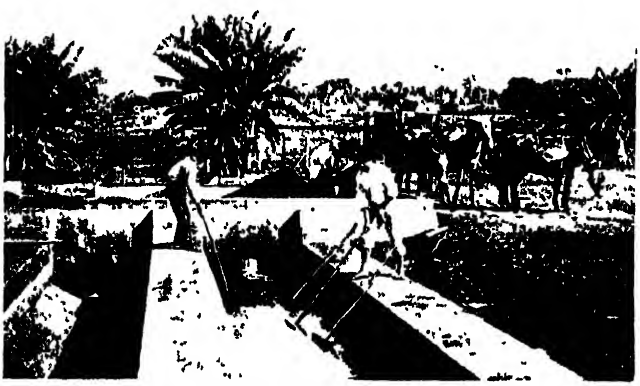
PLUCKING BERRIES FROM THE COFFEE TREE ON A PLANTATION IN SAO PAULO, BRAZIL

DRYING COFFEE BERRIES BY EXPOSURE TO THE SUN ON AN ESTATE IN SAO PAULO

These photographs are by courtesy of the State of Sao Paulo Pure Coffee Company

maintain her commanding position. It is also an explanation of the patient research that our botanists in Ceylon and Trinidad are making with a view to discovering a berry of an incomparable quality.

It is impossible to compete with the Brazilians in cheapness and quantity, and our planters could only make a special market for themselves by the discovery and cultivation of some new variety of coffee plant whose berries have an unrivalled savour and aroma. A hot, moist tropical climate, with a high rainfall, and a rich, well-drained soil at a height of two thousand feet above sea level, is best for a coffee plantation. For though excellent coffee can be grown in dry regions, the crop is usually very small. In a moist climate, no nursery is used, for the seeds are planted directly in the fields, at a distance of from ten to fifteen feet apart. In Brazil, catch-crops of maize and beans are cultivated between the young shrubs. They not only yield a good return, but serve to shelter the coffee from the sun. In some countries, permanent shade-trees are often planted; this is not done in Brazil or Jamaica, but it is said to be absolutely necessary in Porto Rico.


WASHING COFFEE BEANS IN SAO PAULO, BRAZIL

As a rule, the coffee shrub first flowers in its third year, bearing then only a small crop. It is in the fifth year that the planter reaps the full fruit of his labour. A coffee estate in full flower is a very beautiful sight, but its glory quickly passes. The setting of the fruit occurs within twenty-four hours; then seven months and more are necessary to ripen it. The dark red cherries are stripped from the branches by hand in Brazil, but in Arabia they are allowed to fall off naturally, on to a cloth spread beneath the tree. This ensures only quite ripe fruit being collected, and is no doubt one reason for the excellent qualities of Mocha coffee. The Arabians also keep to the old-fashioned method of spreading out the cherries on stone drying-grounds, and exposing them to strong sunlight. In two or three weeks the pulp dries, and is then removed by pounding the fruit in a mortar. In Brazil, the wet method of preparation is coming generally into use.

The cherries are put into pulping-machines, that consist of a thing like a huge nutmeg-grater revolving close to a curved metal plate. Between the grater and the plate there is no room for the cherries to pass, and they are ground to pulp. The mixture of pulp and seeds travels into a vat full of water that is kept agitated by machinery. The heavy seeds settle to the bottom, while the lighter pulp is removed by an overflow of water. The beans are drawn off by another stream of water into a large sieve, and from there they are taken to a fermentating vat. They ferment for perhaps two days, until the pulpy layer that clings to the bean is removed. The beans are then sent into another vat, through which a shallow stream of water runs; and there they are trampled by the bare feet of the working people, and rinsed and raked by machinery until the parchment coverings are quite clean. During this washing process the beans which have not developed properly rise up and float on the surface, and they are collected for making inferior coffee.

After washing, the beans are dried, either by sunlight or artificial heat, and then their silver parchment skin is peeled off by machinery. The machines are of various types, but the essential operation of all of them is to crack the parchment without damaging the bean. The light pieces of skin are removed by a winnowing fan, and another rubbing and winnowing instrument gets rid of the silver skin, leaving the beans clean and in the condition of ordinary unroasted coffee. Some Central American States, however, such as Costa Rica and Guatemala, send us their coffee with the skin on; this is known in the trade as parchment coffee. It is done partly to save the planters from the expense of erecting machinery, but mainly because freshly

husked coffee is of a brighter and more attractive colour than the other sort. And as colour is a matter of much importance in the market value of the berries, London-cleaned parcels fetch a higher price.

In London, parchment coffee is shot into a hopper, covered with a grating to catch sticks and other refuse. It passes into a long, cylindrical machine fitted with blunt knives that break off the parchment. In issuing from the cleaner, the beans fall through a second hopper, to which is attached a powerful fan that blows the broken skins away. The clean beans then go through three or four sieves; and in coffees of good grades hand-picking is necessary. It is done by boys or girls, who work a foot-treadle that moves a sheet of canvas. Upon this the coffee slowly falls and separates, so that all imperfections can be quickly seen and removed. The dust and broken parchment sometimes amount to 20 per cent. of the original shipment. After the beans come on the market they only require roasting and grinding to be ready for use.

Several populous nations, and the Germans in particular, seem now to be becoming cocoa and chocolate drinkers instead of coffee-drinkers. In the United States there has been an increase of 70 per cent. in four years in the consumption of cocoa products. In Germany, for the same period, the increase was 61 per cent.; in France, 21 per cent.; in the United Kingdom, 11 per cent. No doubt much of this remarkably large and sudden increase is due to the growing popularity of the various kinds of chocolate sweetmeats. But it must also be attributed in part to a growing taste for cocoa beverages at the expense of the morning cup of coffee that the Americans, Germans, and French used to prefer. The fact that the product of the cacao-tree is a food-drink as well as a stimulating beverage is no doubt partly responsible for its increasing popularity. But the main factor in the matter is, we think, the recent improvements which have variously been made in the machine processes of its manufacture.

COCOA BEANS GROWING OUT OF A TREE STEM IN ECUADOR

Cocoa is naturally somewhat too fatty a beverage, and the ground kernels are also somewhat insoluble. So the modern manufacturer has been faced with the difficult task of reducing the fat of the kernels, and making the ground powder rapidly soluble in boiling water. Thus the manufacture of cocoa in a fine and convenient form, has involved certain chemical and mechanical problems far more difficult of solution than the problems of tea and coffee manufacture. This is the reason of the long delay in the widespread popularity of the "food of the gods," which Cortes, the conquerer of Mexico, introduced into Europe in 1528

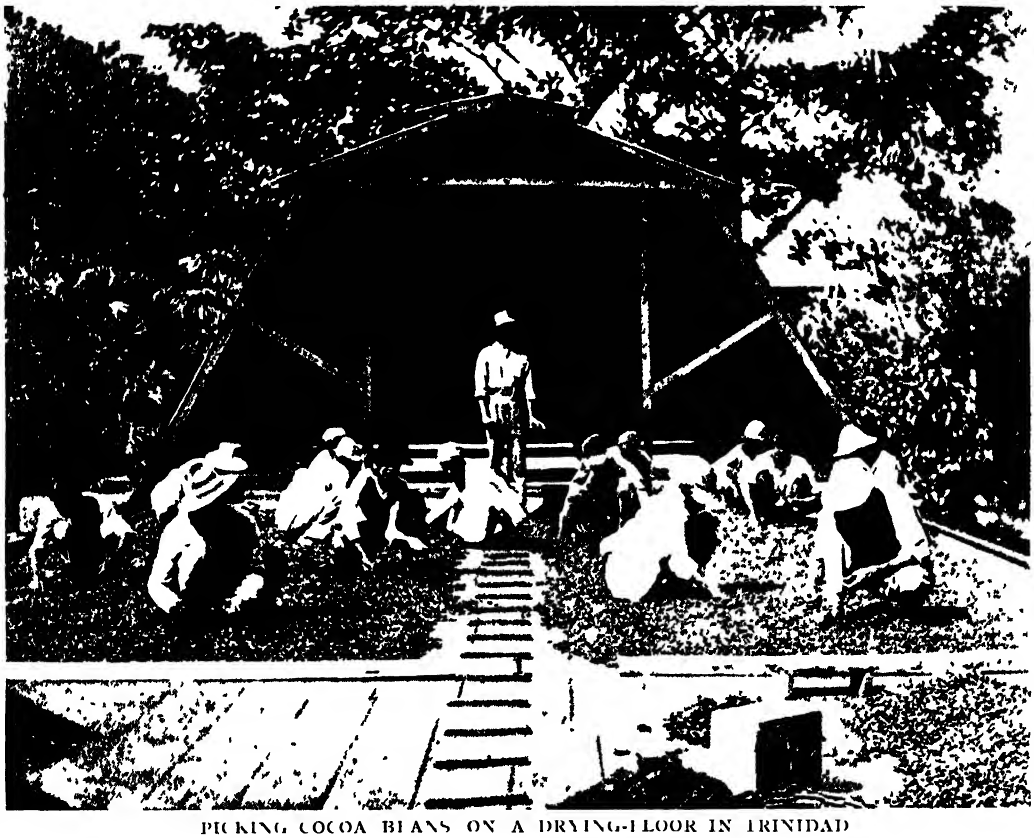
FROM SUN-FILLED POD TO BREAKFAST CUP

CUTTING DOWN AND GATHERING THE PODS OF THE CACAO-TREE ON A CEYLON ESTATE

OPENING THE PODS AND SHELLING OUT THE COCOA BEANS BEFORE FERMENTATION

when he returned to the Court of Spain. For many years the Spaniards closely guarded the secret of chocolate preparation, which they learnt from the Mexicans, but in 1606 an Italian discovered the process of roasting the beans, and revealed it to the rest of Europe.

The French started to grow cocoa in Martinique in 1679, about the same time that the Spaniards began to cultivate it in the Philippine Islands. Our nation also took to planting cacao-trees in the West Indies and Guiana, but the most successful of the new planters were the Portuguese, who have made Brazil and San Thomé, in Africa, the rival centres of the new industry. But the British planters are likely to overtake the Portuguese. Their ancient plantations in Trinidad are excelled in productiveness only by those of Brazil, San Thomé, and Ecuador; and the output of cacao from British West Africa has increased from 9586 tons to 23,611 tons in three years, which surpasses Trinidad, and makes British West Africa a dangerous rival to Brazil.



PICKING COCOA BEANS ON A DRYING-FLOOR IN TRINIDAD

The cacao-tree sometimes grows to a height of forty feet, but in cultivation from fifteen to twenty-five feet are the usual limits of size of fully grown trees. There are many wild varieties, some of which are coming into cultivation. Yet the cacao-tree proper, which is a native of the tropical regions extending from Mexico to Brazil, still supplies the greater quantity of beans for cocoa and chocolate making. The small red flowers are curiously carried on the trunk or main branches. They are succeeded by pods of a cucumber shape, that turn from green to red as they ripen, a process which takes about four months. The trees are usually raised in nurseries, and planted out in warm, low-lying, sheltered plantations. It is best for the trees to be protected from the tropical sunlight, and the planters are finding a new and large source of profit in the use of rubber-trees as a shelter. When the trees are three or four years old they begin to flower; and after they have once produced fruit, regular crops may be obtained, with proper care, for fifty or more years. A cacao plantation is thus a valuable property, and where rich jungle soil is available a skilful planter, possessing an adequate supply of labour, can often make a large

fortune in a few years. A man with some capital and a good constitution and an inclination to work could make money quicker with a cocoa plantation in British West Africa or Brazil than in any other agricultural operation in any part of the world. It is best to work for experience at the beginning instead of buying it, and then lay out about half one's capital in clearing and planting a grant of jungle land.

The ripe pods are gathered by means of a hand-knife, and the pods are then broken and the beans removed and allowed to ferment in vats until they acquire a cinnamon-red colour. It is in the process of fermentation that skill and experience are of vital importance. Certain microbes in the vats or fermenting sacks attack the embryo of the bean and kill it, and then fermenting agents known as enzymes diffuse through the dead tissues and alter the composition of the bean. The process lasts from nine to twelve days, and shrinks and toughens the skin and alters the colour and taste of the kernel. When the required colour and aroma are obtained the beans are stirred and scrubbed under running water and made clean and smooth, and spread out on drying-floors and dried either by sunlight, hot water or steam pipes. Then packed in sacks they are ready for the market.

[illegible]

After buying the beans in this state, however, some manufacturers submit them to further fermentation. This is done by soaking the beans in water for two days, and drying them off in a mild heat. The beans then usually pass through a sorting and cleaning machine that rocks them through a series of sieves of varying mesh and winnows away the dirt and hollow beans by means of a power-driven fan. It is necessary to sort the beans so that the next process of roasting, which is an operation of great delicacy and far-reaching effect, may be perfectly performed. It does not do to roast a small bean with a large bean, for though they may be naturally of the same quality, they will differ very considerably after the same treatment. By arranging the beans according to size the manufacturer is able to submit them to a varying roasting process that tends to keep them of even quality throughout. The roasting is done on a large scale by means of machines through which hot air or gas is circulated with a forced draught. The roasting process, whether conducted over an open fire or in a machine, develops the aroma of the beans, changes their colouring matter, and renders their starch grains soluble.

After roasting the beans are rapidly cooled down on a cooling machine, and while still slightly warm they are passed between rollers that break the husks and collect and fan and clean the nibs. In adulterated cocoa or chocolate, however, some of the roasted husk is left to be ground up with the nibs. But honest manufacturers not only keep the nibs perfectly pure, but pass them through another machine which extracts the hard gritty germ which will impart a coarse flavour to the finished product.

When free from their husks and germ the nibs are milled or ground. In milling they are heated as they fall on the milling stones, and by reason of their large percentage of fat they are reduced by the heat to a liquid state, and melted and ground together. The cacao flows out from the mill in a warm mass and then solidifies in pans. Thus are formed the blocks of raw cacao which are ready to be mixed with sugar and flavouring matter for the manufacture of chocolate, or to be remelted and sent through a hydraulic press for the extraction of their fat. Some years ago it was a general practice to add a considerable amount of starch, obtained from potatoes

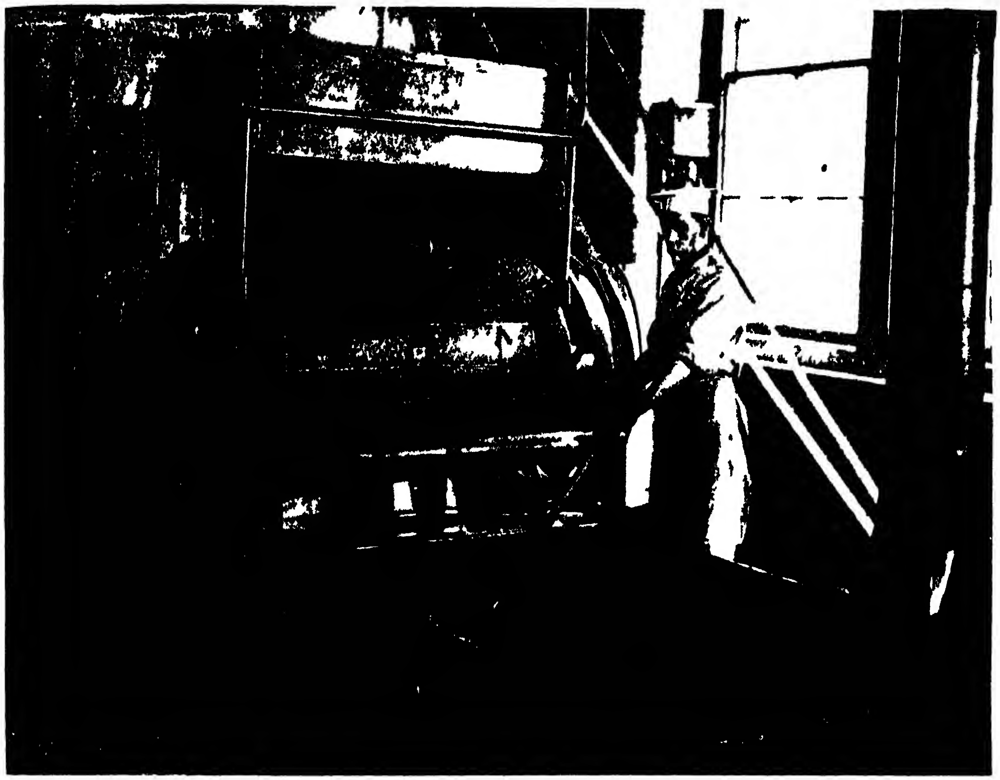
wheat, arrowroot —to the raw cocoa. This was done to balance the natural amount of cocoa fat, and obtain a mixture that could be quickly made into an emulsion by the addition of boiling water. The method is still used by some well-known firms, in spite of the fact that some authorities regard the addition of starch as a process of adulteration. The more recent method of making cacao readily miscible with water is to treat it with some alkali—potash, ammonia, soda, and magnesia being largely used. But many chemists, while acknowledging the superiority of the beverage so obtained, are not prepared to admit that the inclusion of chemicals is without effect on the health. In the United States and Austria the sale of cacao with any added alkali is prohibited; and in Belgium, Italy, Switzerland, and Roumania the quantity of alkali is restricted to 2 or 3 per cent.

This is the amount that naturally occurs in the cacao mass, while examples of treated "soluble" cocoas contain about double the quantity of alkalis. Cocoas from which most of the fat has been removed, without any subsequent chemical treatment, are much to be preferred; and the powder should be ground so fine that it will pass through a sieve with ten thousand holes to the square inch. A harmless way of preparing a cheaper cocoa is to mix it with boiling sugar. But here, as in the case of the starch preparations, the purchaser obtains a large proportion of a cheap substitute in place of the finely ground cacao nibs. It is better to pay a good price for absolutely pure and finely ground powder and mix the much cheaper sugar in it according to taste. This is really more economical.

THE HUSKER MACHINE THAT REMOVES THE HUSKS AND SORTS THE COCOA NIBS

It is doubtful if any breakfast beverages besides tea, coffee, and cocoa will come into general use. But there is possibly a field of development open to the planters of the holly-like maté-tree of Paraguay and South Brazil. Though the taste of its leaves is peculiar and difficult to be accepted, yet millions of South Americans have grown greatly to like this wild tea. Maté tea, moreover, possesses a useful medicinal property, in addition to its stimulating principle, and its use may therefore spread to Europe.

COCOA SUBMITTED TO HEAT AND PRESSURE.

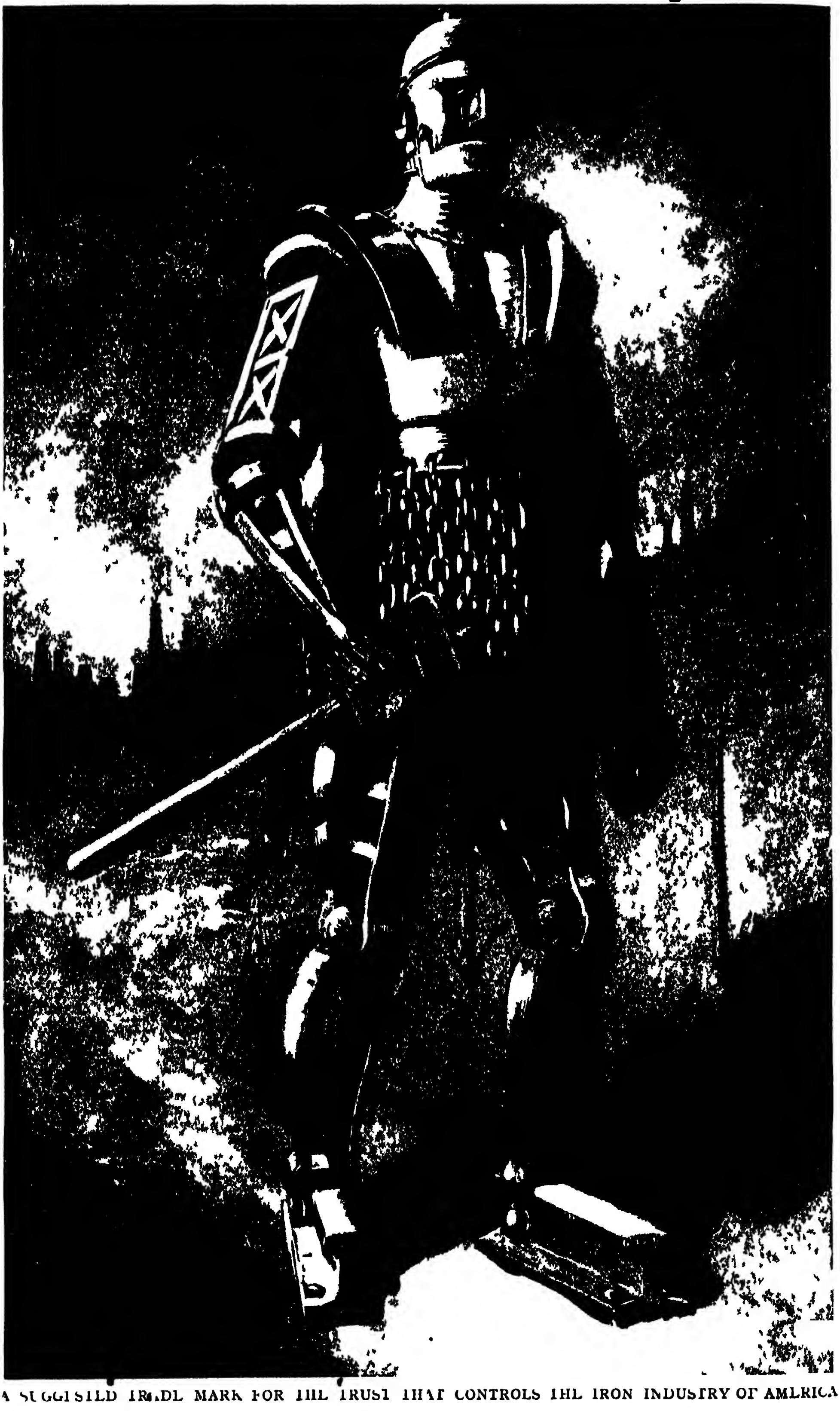


ROASTING COCOA BEANS TO DEVELOP THE AROMA AND MAKE THE STARCH GRANULES SOLUBLE

HYDRAULIC PRESSES FOR REMOVING FAT FROM BLOCKS OF MILLED COCOA

Some of the photographs on these pages are by courtesy of Messrs J. S. Fry & Sons, Messrs Cadbury Bros. [illegible] the Wholesale Co-operative Society

AMERICA'S FRANKENSTEIN—THE IRON MAN



A SUGGESTED TRADE MARK FOR THE TRUST THAT CONTROLS THE IRON INDUSTRY OF AMERICA

COMBINATION & MONOPOLY

The Use and Abuse of Large-Scale Trading, and its Relation to National Wealth

SOUND AND UNSOUND CONTROL OF PRICES

Our study of the growth of the application of the co-operative principle to trade and industry brings us to the consideration of combinations and monopolies as they have arisen in modern times, and the part they play in the national economy.

The joint-stock principle, combined with the necessity for the use of large quantities of costly plant and machinery in modern industrial operations, compelled the abandonment of a great deal of small-scale manufacture and trade. Companies and corporations, utilising the combined capitals of a large number of subscribers, have come to wield enormous powers, and possibilities of manufacture on the grand scale have been realised, to the discomfiture of old-time economic theory. Adam Smith, writing in 1776, said that joint-stock companies could never come to play a great part in trade because they were compelled to act through hired servants, and hired servants could not be expected to look after their employers' interests as private capitalists working on their account studied their own interests for themselves. He was confident that the future would have no place for many big companies.

Writing two generations later, John Stuart Mill gave a more considered judgment in the matter. He saw clearly that joint-stock companies possessed great advantages, but he was still unduly impressed by Adam Smith's argument as to the superiority of private management. He saw, however, that the managers of joint stock companies could be given a real interest in the concerns, and that a rich company could afford a remuneration sufficient to attract persons of the highest attainment. A private manufacturer may make a few hundreds or a few thousands a year, and if industry is much subdivided it is clear that the great majority of masters would make hundreds rather than thousands. A great joint-stock concern, on the other hand, can afford to pay its managing director something in thousands a year, and perhaps a bonus on profits, and even its sub-managers may be better paid than they would be if heads of small businesses. This was not realised by the old economists. Moreover, division of labour arises in a big concern which enables specialisation of a function to be carried out in connection with management. In a small manufacturing business owned by a captain capitalist, the head has, in practice, to manage all its departments, for the profits cannot be big enough to salary first class men for each department. A great joint-stock concern, on the other hand, can appoint highly paid specialised managers to each branch of its undertaking, and secure an efficiency forbidden to the small capitalist.

So it has proved that Adam Smith was altogether wrong as to joint-stock companies, and that John Stuart Mill was too much impressed by his great predecessor. Today the greater part of British industry, as of German and American industry, is carried on by joint-stock undertakings. It is of interest to see how far this has proceeded. If we turn to the assessments to income tax of the profits of companies, firms, and persons in the United Kingdom for the last year for which figures are available (1909-1910), we find that the following assessments were made.

INCOME TAX ASSESSMENT OF PROFITS OF (1) COMPANIES, (2) FIRMS, (3) PERSONS NOT EMPLOYEES, FOR FISCAL YEAR ENDING MARCH, 1910.

		£
(1)	Companies ..	285,500,000
(2)	Firms	76,000,000
(3)	Persons not employees	100,000,000

Moreover, the "firms" and "persons not employees" include a number of solicitors, architects, doctors, and other professional men, so that the proportion of *industry* controlled by companies is even greater than the above remarkable figures indicate.

What we have said has application to industry, and not to agriculture. The latter is still ruled by small capitalists. A large farm wields small capital when considered on the scale of modern industrial operations, and a very large amount of the world's agriculture is still conducted by small, and even by tiny, masters. It remains to be seen whether small culture will for ever survive, and the economic and social questions involved are too many to be discussed here. We may remark, however, that even in countries where small holdings prevail it is found advisable by small farmers to co-operate, at any rate in the purchase of materials and in the grading and sale of products. It is quite possible that through the present century there may be developed processes of fertilisation and stimulation of growth which will make it imperative to employ a considerable amount of capital in agriculture, and if that proves to be the case the small farm will pass even as the small factory has passed.

The Rapid Decline in the Number of Small Manufacturers

The chief thing that stands in the way of agricultural combination is, of course, the difficulty of managing an enormous farm from a single centre. The factory, even of great size, concentrates the work of hundreds or of thousands in a very small space. A farm of a thousand acres means the scattering over a very large area of a comparatively few workmen.

In industry the business establishments are continually increasing in size in all the great countries. Our official British records do not give us any precise information on this point, but general observation and private investigation prove it conclusively. In the United States the clearest evidence of the process is afforded by the official Census of Manufactures. For example, between 1880 and 1905 the number of American boot and shoe factories declined from 5000 to 1300, even while their capital increased from forty-two million dollars to ninety-six million dollars. In the same twenty-five years the number of American makers of agricultural implements declined from nearly 2000 to 650, although the aggregate capital employed in the industry increased more than threefold.

Let us review the advantages of operation by joint-stock companies. The principle of combining capitals in joint-stock form enables undertakings to be attempted which a single individual would rarely or never put his hand to. The London and North-Western Railway, for example, has a capital of £125,000,000, and it is impossible to conceive of a single individual risking such a gigantic sum. Without the joint-stock principle the railways of Britain would either have been built by the State or they would not have been built at all.

Command of Capital and Use of Division of Labour in Joint-Stock Enterprise

It is very much the same with the establishment of great lines of steamships, undertaking to maintain continuous and periodic communication between far-distant points. An amount of capital is called for which it is difficult or impossible for an individual to command. Joint-stock enterprise solves the difficulty by placing under a single control the capital subscriptions of a large number of great and small investors.

Joint-stock enterprise, by enabling businesses to be conducted in large, makes practicable the many advantages which arise from large-scale operations.

The principle of the division of labour can be used very fully, not only in regard to workmen, but in regard to direction. Manufacturing on a large scale has alone rendered possible the full development of the use of machinery to which we referred in the last chapter. An exceedingly large capital is needed to command the full range of complicated and costly machines necessary for the economic conduct of many modern processes of manufacture. In this respect, as in others, there is a point at which economy through increase of size ceases, but the point is usually at a very high level indeed.

Financial Advantages in Conducting Business on a Large Scale

The large establishment can secure the best supplies of material, and in some cases can come to control certain sources of supply, as when large British iron companies are found owning iron-ore mines in Spain to ensure the economic command of an essential of the trade. The buyer of enormous quantities of raw materials can secure them at unusually low prices, and this faculty is especially valuable in trades in which supplies of materials, as is so often the case, are exceedingly variable in quality. A large builder, for example, can watch the timber market and buy when it suits him,

while the small man has to buy when he is compelled and to take what he can get.

A large business can command loans at a lower rate of interest than a small business, and the saving in this regard may at times be considerable. In some cases the large producer can obtain lower rates of transportation both for his materials and his products. This advantage does not obtain in countries which possess State railways, but it has been a considerable factor in the United States, where combinations have been especially fostered by transport arrangements between big corporations and the railway companies.

What is the Limit of Advantage in Concentrating Business?

In respect of all these advantages, there is, of course, a limit at which the advantages of concentration or combination ceases. We may put it that, at each increase of size, the advantage of combination, although still existing, may become less marked. Experiment seems to show, however, that many businesses in very large countries may with advantage be extended to cover the entire bulk of the industry within the country's borders.

It is not, however, the desire to attain to the most economic form of production which actuates men in combining capitals. The joint-stock principle and the necessity for employing large plants naturally led, as we have seen, to capital concentration. As soon as capital concentration reached the point at which the number of members in a trade became comparatively limited, the possibility of combination for the purposes of securing better prices became more feasible. Such a combination is possible, of course, for producers, however many in number; but it is obvious that while the number of producers in a trade is very great, it is exceedingly difficult to get them all to agree to form a price combination. The smaller the number of capitalists in a trade, the easier it becomes for them to put their heads together for monopolistic purposes.

The Dividing Line—the Limiting of Cost Good, but the Control of Prices not Good

The desire to end cut-throat competition and to obtain higher prices has had a great deal to do with the growth of capital concentration. It is at this point that we come to the dividing line between what is good and what is evil in capital combinations.

So far as combination to reduce cost of production is concerned, concentration is all for good. For example, if we consider the great oil industry of the United States, and imagine it controlled by a large number of small capitalists, the transport of oil would be still a matter of putting oil into barrels and paying the costly charges of the transport of those barrels. As a consequence, oil would be very high in price. Because the oil industry of the United States has come under the control of huge combinations of capital, it has been possible to build great pipe-lines by which the oil is transported at incredibly low costs, which means cheap oil.

But observe that when, through an enlarged use of capital and a combination of capitalists, an industry has become monopolised, it may withhold from the public a very large part of the advantages which have accrued from combination. That is to say, the combine may actually reduce prices even while making monopoly profits. It is not a defence, therefore, to such a combination merely to show that price is not higher than it used to be before the combination was formed. If the combination is withholding from the public the advantages which the public have a right to expect from the proper and economic use of plant, then the combination is acting as a taxing monopoly.

The Right of a Nation to Organise Industry for Itself

A nation, at any given moment of its development, has the right to expect that it shall be able to avail itself of the most economic means of work, and to organise itself for work in such fashion as to use its land and capital to the best advantage. Consider the United States as a concrete instance. It is a rich nation, gifted with most of the desirable natural resources known to man. It has a huge population. It has had many capable inventors, and it, of course, has at its command the inventions of all the clever men that ever lived. Why, then, should it not avail itself of all these things in the best possible way? Why should it submit to have its resources handled, on a large scale, truly, but mainly for the benefit of huge combinations of capital?

We find the American people increasingly questioning themselves on the subject, and American legislators endeavouring to curb the power of the "Trusts," and it is not surprising that it is so. How important the subject has become in America will be seen from the following quotation from Professor John Bates Clark, of Colombia University.

"That is the problem which we have mainly

to consider, what can we do with modern monopolies? Can we do anything with them? Will they rule us, or shall we rule them?

"It is essential to perceive that it is not the problem whether, if it comes to an out-and-out fight, we can or cannot crush the monopolies. That we can do if we must, for it is usually easier to smash a thing than to shape it to your mind, and if there really were an ultimate test of strength—if we found the monopolies out-and-out unendurable, if we found them really threatening our liberties, and concluded that the only thing we could do was to destroy them, we could and should do it. The people have at different times in history succeeded in doing a great deal of such destroying.

"We know well, however, that that is not what in our own interest we ought to do. We know already that the real problem for us is to get the benefit of the producing power which these enormous consolidations have, to make them work for us instead of preying upon us. We need so to control these gigantic monsters as to transform them into beasts of burden instead of predatory animals that make our living insecure. Can we do that? Can we throw to the winds the idea of doing a destroying work, and save what is good, and stamp out what is evil in these great consolidations?"

On their part, combinations always declare that it is not their desire to raise price, and that they have not raised price. But it is clear that the managers of a combination are not in business for love; that they did not combine for nothing; and that they can hardly be expected not to charge "what the traffic will bear." In trade, every man asks the price he can get, and the price he can get depends on the relation of supply and demand. In the ordinary case of competitive trade, the producer has no control of demand, and only such control of supply as his own small output gives. The big combination, on the other hand, is in a position more or less effectively to control supply, and, human nature being what it is, we cannot expect trust managers not to take advantage of the temporarily secure position which monopoly creates.

That capital combinations of various kinds do actually control prices it is impossible to deny. Price maintenance is a striking feature of modern trade, and it affects retail as well as wholesale prices. We shall see presently the forms which combination takes. Let us see at once what can be done with prices. Take the question of railway fares. There are five different routes from London to Manchester, from Euston, St. Pancras, King's Cross, Marylebone, and Paddington respectively, but inquiry shows that the fare in each case is precisely the same—viz., 15s. 5½d. third class. That is obviously an "arranged" fare, the five companies concerned having agreed to charge the same rate. The agreement is easily possible because the number of competitors is so few. The "Parliamentary" fare is a penny per mile, and they agree not to undercut that price. It is the same with the route London to Jersey, in which train and steamboat are involved. There are two routes, but the fare in each case is the same, namely, twenty shillings for the third class.

We turn to garden implements, and we find a certain much-used article advertised by several different firms at exactly the same prices. Here they are in extenso.

PRICES IN 1912

	Maker A		Maker B		Maker C.		
	s.	d.	s.	d.	£	s.	d.
12-inch	89	3	89	3	4	9	3
14-inch	108	3	108	3	5	8	3
16-inch	127	6	127	6	6	7	6
18-inch	144	6	144	6	7	4	6
20-inch	157	3	157	3	not quoted		

Now, it is clear that these figures are not a marvellous coincidence; they must be the result of a price combination. This is of considerable importance, because there is no actual consolidation of capitals. The three firms are separate, and they advertise and carry on business quite distinctly. Yet they have agreed to charge the same price for the same standard article. It is a case in which, without the benefits of consolidation, we get the disadvantages of artificial prices.

Another case of similar sort is concerned with a certain much-practised art in which prepared paper is employed. Here, again, we find what at first sight seems an extraordinary agreement as to prices.

PRICES OF PAPER

Make	Per gross				
	Size A	Size B		Size C	
	d.	s.	d.	s.	d.
Firm A	8	1	10	4	8
Firm B	8	1	10	4	8
Firm C	8	1	10	4	8
Firm D	8	1	10	4	8
Firm E	8	1	10	4	8
Firm F	8	1	10	4	8

These are the leading producers in this line of manufacture, and they find it possible by agreement to maintain their prices at a certain level. As in the case of the garden implements, the firms are not consolidated, so that the public does not gain the normal advantages of combination. It suffers, on the other hand, the disadvantages of combination through price maintenance. We may judge from this what is done with prices when a trade is controlled by a single firm.

The practice of price maintenance has so far invaded retail distribution that we find the general price list of a well-known store contains the following notice.

NOTICE

Owing to the action of certain manufacturers of Proprietary Articles in fixing the lowest retail price at which their goods are to be sold, Blank & Co. are unable, on the goods marked "P," to give their customers the advantage in price they would desire to do.

And amongst the articles so distinguished in the list we find the following.

Meat extracts	Cigarettes
Boot polishes	Tobacco in packets
Cocoas	Patent "medicines"
Infants' foods	Perfumes
Golden syrup	Lawn mowers
Lime juice	Garden rollers
Marmalade	Soaps
Whisky	

These cases are not always instances of maintenance through combinations. They are sometimes an exhibition of the great power possessed by large individual firms, who feel strong enough to refuse to supply their products to retailers on any other terms than that a certain minimum figure shall be asked for them. On their part, retailers often lend themselves to the practice in order to maintain the large margin of gross retail profit which is necessary to give them a small margin of net profit.

We have said that in the United States consolidation and combination has proceeded far, and the official investigations of the Trusts which have been made in America furnish us with better particulars than we have of combinations in the United Kingdom. Perhaps the most remarkable combination in the world is the United States Steel Corporation, which was founded in 1901 with a capital of over 1402 million dollars (or over £280,000,000), and which now has a capital of about 1500 million dollars. This gigantic organisation covers every branch of the iron and steel industry, from iron-ore mines to the manufacture of wire, plates, tubes, or bridges. Its property includes extensive mines, lands, and railways, as well as the ordinary plant of the iron and steel manufacture. It actually embraces about half of the entire United States iron and steel industry, and that means that its business is much bigger than all the iron and steel businesses of the United Kingdom put together. The truth of this will be seen from the following statistical statement.

UNITED STATES STEEL TRUST COMPARED WITH THE UNITED KINGDOM IRON TRADE.

	Total Output of the United Kingdom 1910	Output of the U.S. Steel Corporation 1910
	Tons	Tons
Iron ore produced from own mines	15,200,000	25,200,000
Pig iron produced	10,200,000	11,800,000
Steel ingots produced	6,000,000	14,200,000

The net profits of the Steel Corporation vary from one hundred to one hundred and fifty million dollars per annum. When this remarkable combination was formed in 1901, it represented the consolidation of ten great Trusts, and each of these had previously consolidated a very large number of great businesses. Without going into details, it may be said that the ten iron and steel Trusts bought up by the United States Steel Corporation had been formed from over two hundred separate iron and steel firms. At each step in the consolidation the capital was "watered," and some of the undertakings were bought out at fancy prices. The United States Bureau of Corporations has analysed the methods adopted, and the official Commissioner's report states that the real value of the assets taken over by the Trust in 1901 was only 682,000,000 dollars, whereas the capitalisation was, as we have already stated, 1,402,000,000 dollars, so that there was more water than intrinsic value in the capital. The Commissioner adds, however, that the position has since improved in this respect, and that by judicious investment the amount of mock capital has been considerably reduced. It will be understood that the amount of water in the capital hides the real rate of profit, and the official report of the United States Bureau calculates that the real rate of profit of the Trust in 1902 10 averaged twelve

per cent. per annum. The Commissioner expresses the opinion that the control of the iron ores of the Lake regions which the Trust has acquired give it a quasi monopoly.

Another Trust which has been officially investigated by the American Bureau of Corporations is the Tobacco Combine. It shows that the American Tobacco Company and its affiliated concerns control substantially three-fourths of the business of tobacco manufacturing, apart from cigar manufacturing, of the United States. The steps by which this gigantic concern has risen are briefly as follows. The American Tobacco Company was organised in 1890, and combined the principal American cigarette firms. During the 'nineties it built up a considerable trade in smoking tobacco.

In 1898 the Continental Tobacco Company was organised to consolidate the tobacco manufacturers, and to it the American Tobacco Company transferred its tobacco business. The American Tobacco Company held stock in the Continental Company, and both companies were controlled by the same heads. In March, 1900, the American Snuff Company was organised, combined the leading snuff manufacturers, and took over the snuff business of the American Tobacco and Continental Companies. In January, 1901, an American Cigar Company was formed in the same fashion. In June, 1901, a Consolidated Tobacco Company was formed, not to manufacture, but to hold stock of the other companies and concentrate control. Finally, in 1904, the American Continental and Consolidated Companies were merged under the name of the American Tobacco Company, and by stock ownership it directly or indirectly dominates all the companies of the combine.

Not only so, but it has a subsidiary, the British-American Tobacco Company, approximately two-thirds of the stock of which it holds, most of the remainder being held by the Imperial Tobacco Company, which is a British combine. In 1906, says the official report, the Tobacco Combine consisted of no less than eighty-six corporations doing business in the United States and its dependencies and in Cuba, in addition to various corporations controlled by the British-American Tobacco Company, and doing business exclusively in foreign countries. Thus we see that an enormous proportion of the tobacco business of the world, irrespective of national boundaries, is more or less compactly organised into a single price-controlling and protective agency.

The following table will show what a tremendous hold the combine has on the American tobacco trade.

PROPORTION OF OUTPUT OF THE SEVERAL CLASSES OF TOBACCO PRODUCTS MADE BY THE COMBINATION, 1907.

	Total output	Output of the com	Per cent made by the com
Cigarettes, number	5,270,556,938	3,975,809,425	75·4
Little cigars ,,	1,074,083,976	975,692,600	90·8
Cigars ,,	7,302,029,811	1,057,822,004	14·5
Tobacco :			
Plug & twist (lb.)	172,002,513	132,484,125	77·0
Smoking ,,	179,172,512	123,412,393	68.9
Fine cut ,,	12,457,917	10,135,740	81·4
Snuff ,,	23,305,340	22,307,105	95·7
Total manufactured tobacco and snuff (lb.)	386,938,282	288,339,363	74·5

It will be seen that, apart from cigars, the combine has the lion's share of the tobacco trade of a nation numbering nearly one hundred millions of people.

Such are the industrial developments of the largest civilised country of the world. Other details might be given, but we have said enough to show the almost incredible degree to which consolidation has been carried in America. If the facts baldly stated above were not actually accomplished, we should scarcely credit the possibility of their achievement. Whatever else may be said with regard to them, it is impossible not to perceive that they are a tribute to the organising powers of modern business men. It may help us to see, in considering the future of trade, that we need not be hampered by the ideas which misled Adam Smith and many of his successors.

In the United Kingdom combination has not proceeded to such lengths. The business men of the United States have had to deal with resources very much greater than ours, and this, no doubt, has had much to do with their capacity for thinking in large quantities and for the mental daring with which they approach tremendous problems. Nevertheless, the United Kingdom can produce in the London and North-Western Railway with its £125,000,000 of capital, the Great Northern with its £60,000,000 of capital, the Midland Railway with its £194,000,000 of capital, or the Great Western with its £99,000,000 of capital, proof that its captains of industry are capable of controlling great units of work, and in a considerable number of branches

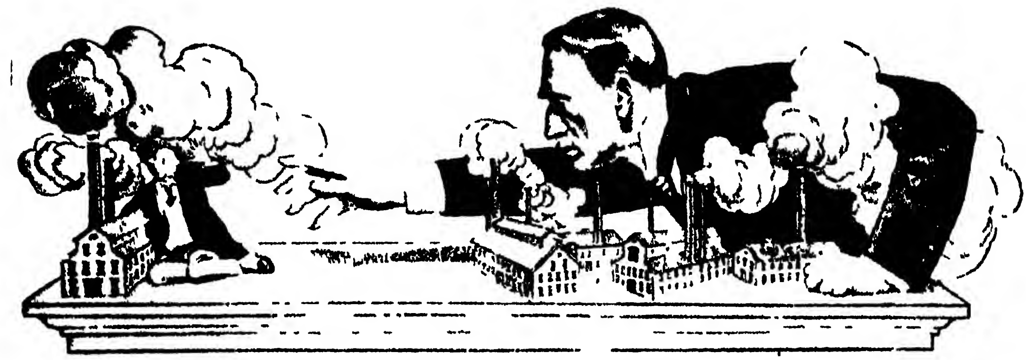
of manufacturing industry great combinations have arisen, although not of the size of the American Trusts. It has also to be remembered that in the United States Trusts are undoubtedly furthered by the high tariff, which by making foreign competition difficult or impossible, helps rings of home manufacturers to gain control of the home market.

An invaluable review of the Trust movement in British industry has been published by Mr. H. W. Macrosty, in which he shows how the combination movement has proceeded in the iron and steel, extractive, textile, chemical, milling, tobacco, liquor, transport, and other trades, and has spread even to retail distribution.

In the British iron and steel trade, which, as we have seen, is as a whole smaller than the single American Iron Trust, the industry is controlled to an extraordinary extent by a limited number of great combinations.

plant, and there was an exchange of shares with Bell Brothers in order to effect, in the words of the chairman, "more complete union of the interests of the two firms." In 1903 Dorman, Long, and Co. bought up the ordinary shares of the North-Eastern Steel Company, which had a capital of £800,000. The total capital involved in all these transactions now amounted to over £3,000,000, and there have since been further issues. It is a complicated story, which we have told very briefly, but the effect has been that the combine has gained control of raw materials and the extension of products while absorbing competitors and meeting foreign competition by the reconstruction of works and the power of an enlarged capital. Undoubtedly there has been a great increase of efficiency.

A number of other similar combinations might be brought in evidence, but suffice it here to say that by far the greater part of



THE DISAPPEARANCE OF THE LITTLE MAN IN MODERN INDUSTRIAL ORGANISATION

A typical example of the developments of the British iron trade is afforded by the firm of Bell Brothers and the companies associated with it. Bell Brothers were established in 1844, and became a private limited liability company in 1873. In January, 1899, it became a public company, Bell Brothers, Limited, with a capital of £1,270,000. It was a self-contained firm producing pig-iron. In 1898 Bell Brothers, Limited, joined with the steel firm of Dorman, Long, and Co. in building steel works at Port Clarence. In 1889 Dorman, Long, and Co. became a limited liability company, and in 1899 it incorporated the sheet works of Jones Brothers and the wire works of the Bedson Wire Company.

In 1902 the share capital of Dorman, Long, and Co. was raised to £1,000,000. It was decided to remodel and enlarge the

the British iron and steel trade is now controlled by less than twenty firms. In view of the gigantic character of the American Steel Trust, such a combination as that of Dorman, Long, and Co. seems small, but the difference is one not only of degree but of kind. The American Trust is protected from foreign competition. The English Trust, on the other hand, has no such aid.

As showing, however, that under any fiscal conditions it is possible to erect an almost complete monopoly of trade, we may instance the case of the Wallpaper Manufacturers, Limited, formed in 1900, which consolidated thirty-one firms engaged in the manufacture of wallpaper and other wall decoration materials, and which joined together in one single interest nearly 98 per cent. of the entire trade of this kind in the

United Kingdom. This combination still exists in 1912, and has so far been successful in maintaining its supremacy. It contrived to make a ten years' agreement with the wallpaper dealers, binding them not to sell any other materials than those sold by the company. The nature of this agreement may be gathered from the following circular issued by the combination in 1906.

THE WALLPAPER MANUFACTURERS, LTD.,
125, HIGH HOLBORN, LONDON,
October 17, 1906.

GENTLEMEN,

In view of the fact that certain manufacturers are pressing for orders, permit us respectfully to remind you that by the terms of your agreement with this company you have engaged not to "stock nor cut up patterns, nor issue in your pattern books, nor sell for stock any paper-hangings or any raised materials other than those manufactured by the company."

We have reason to believe that some of our customers, either from negligence or under the advice of interested parties, have been induced to commit small breaches of Clause 18 of the agreement.

In those cases which have come to our knowledge, we have, in bringing the matter to our customers' notice, obtained from them formal recognition of their obligations, and a promise to comply with them in the future; and we have instructed our solicitors to commence proceedings and enforce the payment of damages against any of those who commit breaches of the agreement.

In the general interest, and at the request of a large body of agreement customers, we are writing this letter to all, and take the liberty of bringing the matter to your attention, so as to avoid any chance of misapprehension.

Yours truly,
THE WALLPAPER MANUFACTURERS, LTD.

This company, through the mouth of its chairman, has again and again disclaimed any idea of fleecing the public or of bolstering up prices. It is clear, however, that such a position as the firm holds must at least enable it to control prices to some extent, and it is significant that in 1902 the British combination made a large investment in a large German wallpaper company, and bound it not to send any more wallpaper over to England. The combination appears to be successful in keeping out foreign papers; the imports of paperhangings in 1911 were much less than they were in 1907 and 1908, and it has been stated that a proportion of the imports are actually controlled by the combination itself.

It is a remarkable position which obtains in this trade. The ordinary houseowner or tenant who has sent to him a number of books of wallpaper patterns may believe that he is choosing as a free agent between different firms. As a matter of fact, the books that are sent him are really issued by one shop—the Wallpaper Manufacturers, Limited—and for practical purposes competition does not exist.

The same position obtains in the cotton-thread trade. The woman who goes to the draper's shop and buys a reel of cotton cannot choose but buy one or other of the products issued by a single great agency. There is only one shop for cotton thread in the United Kingdom. In the same way nearly the whole trade in cement is controlled by a single combination, and the bottle trade is in the same position. A friend of the present writer gave him, not long ago, an account of how, in order to evade the bottle combination, he established bottle works of his own, and, although the trade was new to him, contrived to manufacture bottles very much more cheaply than he could buy them from the combine.

In so far as a combine is formed to reduce cost of production, it can be successfully accomplished in any country. In so far as a combine is formed to restrain price, it is more difficult to accomplish that object in a country without a tariff than in a country which is protected. At the same time, it should be remembered that there are methods by which combinations can evade tariffs and render them nugatory.

For example, the alliance which has already been referred to of the American Tobacco Trust with the Imperial Tobacco Company of the United Kingdom means an elimination of competition between them in the respective home markets. There are other similar cases in which combinations of producers in various countries agree upon a division of territory and the sinking of competition. At some time or other, in various ways and in varying degrees, the international trade in sewing cotton, bleach, tobacco, borax, nitrates, rails, screws, etc., has been subjected to combination or agreement in restraint of free competition. Thus, in some measure, the boundary lines of trading spheres of influence have ceased to be the same as political boundary lines.

There is even an attempt to bring the iron and steel trade of the entire world under a single control. In September, 1909, when

Judge Gary, the chairman of the United States Steel Corporation, was dined at Sheffield by British ironmasters, he said: "What is the good of fighting? You win today, but your rival wins tomorrow. The present commercial system is akin to 'beggar your neighbour.' Why not agree to share the trade of the countries of the world on reasonable, friendly lines?"

In pursuance of such ideas, a conference of the members of all the iron and steel producing countries was held at Brussels in July, 1911, "with a view of forming an International Association to extend existing friendly relations between steel producers throughout the world." The delegates elected a committee of thirty-five members, in which the various countries were represented as follows: Austria 3, Belgium 5, Canada 2, France 5, Germany 5, Great Britain 5, Hungary 1, Russia 3, Spain 1, United States 5, total 35. The object of this International Association is to exercise a general oversight of the iron and steel trade of the entire world in all its branches in the interests of iron and steel producers. It may prove to be a preliminary step to the close association and co-operation of those producers. We have the hint of the possibility not of monopoly in a nation, but of monopoly in the world.

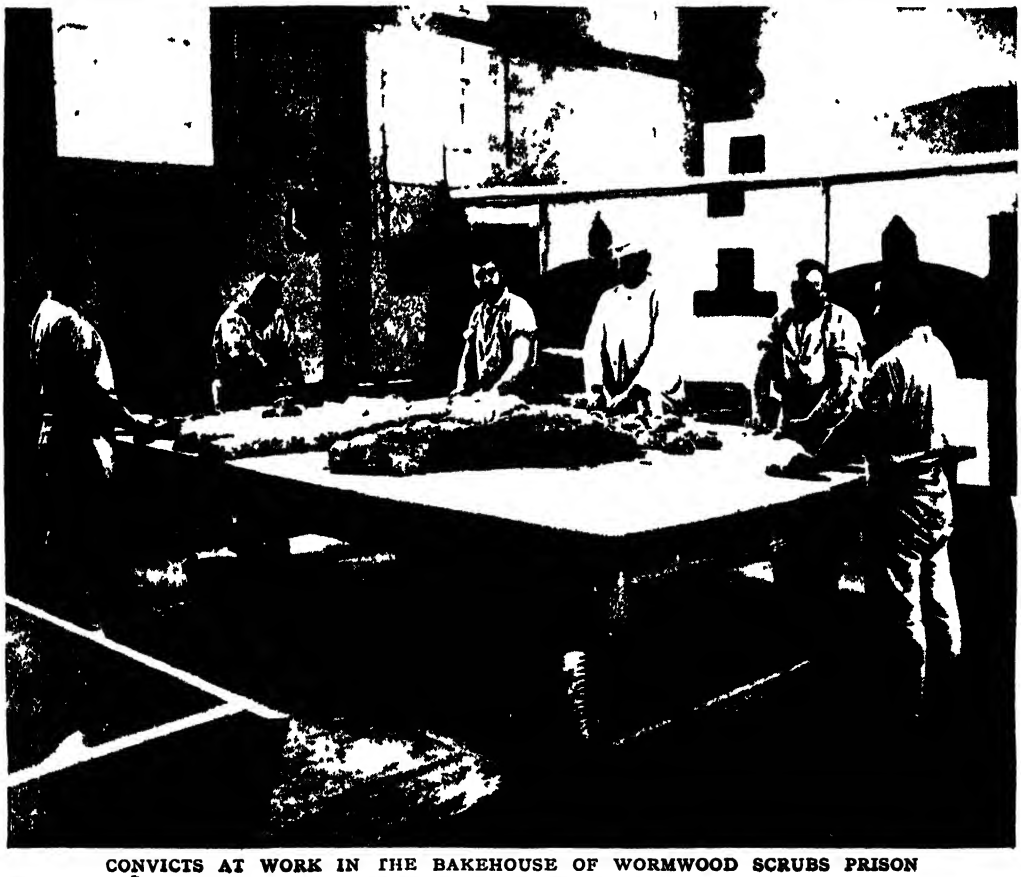
It is clear that civilisation in all countries is faced with great and difficult problems in connection with the Trust and combination movement. We have seen that there is nothing inherently wrong in large-scale trading; on the contrary, the most economic production of wealth is incompatible with small-scale operations. If poverty and want are to be abolished, we must not abolish the only means by which the best results in wealth-production can be secured. The problem resolves itself, therefore, not into destroying or mutilating combinations or consolidations, but into securing that they shall be operated in the public interest. Some economists put their faith in the State regulation of Trusts. The chairman of the United States Steel Trust has himself suggested that the United States Government should control all inter-State industrial enterprises, and that such control should extend even to the arrangements of output and price.

THE NEED FOR STATE WATCHFULNESS AGAINST THE LOOTING PROPENSITIES OF TRUSTS
From the "M ipolis Journal"

Whatever the solution, we need not fear the outcome. We have no more reason to be afraid of the prospect of change in the methods of conducting trade than we have to fear the further inevitable changes which science will bring about in the domain of production. After all, the difference between a great company controlling an entire industry and a number of small masters laboriously producing a small output is of the same kind as exists between a goods train of up-to-date waggons drawn by a powerful locomotive and the rude carts used by our remote ancestors. The main thing which emerges is that man is gaining a greater grasp of material things.

REDEMPTIVE TRADES FOR THE TRADELESS

CONVICTS RECEIVING INSTRUCTION IN BASKET-MAKING IN DARTMOOR PRISON



CONVICTS AT WORK IN THE BAKEHOUSE OF WORMWOOD SCRUBS PRISON

Photographs by Grove and Boulton

RECLAMATION FROM CRIME

The Modern Attempts by Society to Remove from Itself the Reproach of Neglecting Criminality

TRAINING THE CRIMINAL AS A CITIZEN

In our last chapter we pictured the growth within Society of a clan that practically has not accepted for itself the laws made for the protection of all, by general assent, a clan that, for its own momentary apparent benefit, is at war with civilisation. This clan, chiefly located in the considerable centres of population, or wandering through the country, and bred and recruited, for the most part, within a comparatively narrow circle, persists long after men have agreed as to what is real and what is fictitious crime. Time was when any definition of crime divided society widely in opinion; when punishments of a hideous character were in force against so-called offences that now rank as virtues; but crime is now narrowed down to aggression against life, property, or the amenities of life. The range of admitted crime is over a much smaller area; the punishments incurred are less drastic; the treatment of the criminal is not so vengeful, and is more hopeful. Our survey of crime and its punishments, halting at a period of about eighty years ago, was a record of injustice, cruelty, and failure. We have now to discuss steps that have been, or are being, taken to remove crime from our midst--a a long and gradual process, no doubt, but far more promising than the primitive policy of harsh retaliation.

Although this movement to measure punishments justly, and to remember the manhood of the offender, had such a recent beginning in law and its administration, it was foreseeen in spirit long ago, even in our own boisterous land. In that wonderful repository of wisdom "Utopia," Sir Thomas More outlines three objects of a trial of anyone who has broken the laws—the prevention of further mischief, the making of amends for the harm already done, and *the saving of the man.* It has taken us nearly four hundred years to learn that final lesson -the saving of the man. More also saw clearly the major mistake that Society has made all along with its criminals. Said he, "You suffer them to grow up infected, and then, in God's name, you punish them." A volume could not have told the story more exactly.

Before we refer to the bulk of ordinary crime, for which Society itself is responsible largely, owing to its neglect, we must make the admission that, outside of those who are brought up in an atmosphere which conduces to crime, and makes participation in it natural, there are forms of crime that will continue. We must make up our minds to that. A certain amount of crime springs up sporadically, in sheer freakishness, out of unbalanced human nature. By a kind of spontaneous generation it breaks out in the most unlikely places, through temptations offered by education, by the handling of money, and by the undue influence and social kudos associated with money. The sphere of possible fraud has been widened greatly by the growth of commercialism; and ill-balanced minds, associated with laxity of principle, cannot withstand the beckonings of demoralising suggestion. We know, by statistics, how strangely feeble minds and characters are upset by pressures of outward circumstances that leave others completely untouched.

For example, a change in the weather will send up the record of murders and suicides with a bound. This irregular, casual crime, that lingers on the borders of insanity, is a separate problem. But alongside this there is a much greater mass of what may be called regular and almost professional crime, or preparation for it, that needs systematic inquiry, and will respond favourably to wise attention.

The first great secret of securing an honest and law-abiding population is to cut off the supply of criminals from the reservoir of youth. Five offenders out of six are as certainly "contact cases" as are the victims of any epidemic disease. How completely this is so is only known to people who watch, at closest quarters, the lives of the floating, nondescript population of the poorest quarters of the large towns - school-attendance officers, relieving officers, guardians, the police, and philanthropists who grapple personally with such problems as street-trading. They know that many of the children who will be the criminals of the future have never had an equal chance of being anything else.

The Children whom Society Allows to Grow up Infected

As a rule, the parents of such children have not been parents in any moral sense. Physically, mentally, morally, and therefore throughout the whole range of character, these parents are usually weaklings. Probably they, too, have been reared on the borderland of crime. Whatever preventive instinct they have springs from fear of punishment and being found out. The verb "to pinch" is one of the commonest in their vocabulary, and carries with it no moral condemnation. It is a sort of condoned version of the verb "to thieve," and waits only on opportunity. Such people have no control over their children how should they have, seeing that they have no moral reserve whatever, and rely solely on a chance distribution of blows? If the children imbibe at school any sense of morality, it must be an exposure of their parents and a weakening of their control, since it shows their whole life and conversation to be in the wrong. Many of such children are trained to live in the streets and pick up what they can. They are taught to play a piteous part before sentimental noodles, to snivel and beg and lie and thieve. The streets are their real home, and they grow in the atmosphere of crime —and often of sensuality from their tenderest years. As Sir Thomas More said, "We suffer them to grow up infected."

At What Point Ought Society to take Supervision of Children Born into Crime?

Anyone who may think, mistakenly, that this picture is overdrawn must remember that crime of all kinds is always far in excess of the statistics. It is so with crime by adults. A large part is undiscovered, or condoned. And with children the truth is that, usually before they become known as offenders to the extent, say, of thieving, they are pretty far gone in demoralising experience and positive wrong-doing. It could not be otherwise, considering the conditions of their lives. How can Society counteract this initial corruption?

The reply is that, if Society really desires to bring its hereditary crime within control, it must begin earlier to do the work which it will be bound to do later; that is, it must in some way take supervision of the children, and neutralise the taint of their family life. We say this must be done if Society really wishes to solve the problem. Of course, it does not actively wish for a solution, because it does not realise the genuine existence of such a scandal; and, besides, it will ward off any effective proposal by long arguments about the sacred rights of parenthood. The rights of parenthood in these cases are just the same thing as the wrongs of rearing children into lawlessness and crime, a misery to themselves and a danger to the community. Indeed, the only question is *when* shall the public take control of these children? Shall it be before they are infected -if that can be, and the taint is not already genetic — or shall it be with the hope of curing a moral disintegration that has commenced already? The problem can only be judged in its true relations by those who know the after-history of such children.

The Great Danger of Children from Criminal Homes Becoming Criminals

What will happen to them, as certain as the rising of the next day's sun, if they are moulded by parental influences, is that they will either become probationers under the moral supervision of Society's agents; or after fourteen they will be drafted into industrial schools, or the milder form of truant schools; or before sixteen they will be sent to a reformatory; or, escaping all these alternatives till they are over sixteen - perhaps because of the cautionary experience of their parents they will join directly, at a later period, the in-and-out prison population, with a "record" in the police-courts, and perhaps a final career of positive crime. Many will arrive at this end for prison treatment through the official stages we have named, because the early taint, cultivated in childhood, was too deep to be eradicated by Society's devices.

But here, those who satisfy themselves with objections, and never advance to hopeful action, will interpose with the warning that what we are advancing looks in the direction of freeing parents of the

expense of their offspring, and making them an additional burden on the whole community, at even an earlier age than is possible now But it does not follow that the parent should be freed from expense Indeed, the check of expense is essential against unlimited breeding of the unfit, and the imposition of that check will be less difficult in proportion to the supervision and organisation of the early child life of the community.

The Need for a Census of the Location of Crime by Birth

What is needed is a census and location of the birth of probable crime with public care of the child, and manipulation of the parents' resources from the first Home is the source of pollution in myriads of such cases How often is it said, in dealing with the young in children's courts and elsewhere, that the only hope is in getting the child away from its home? Has Society no responsibility for the child-coming into such a home? Birth to crime is much the same, in this connection as birth to disease insanity or feeble-mindedness and if Society is compelled, for the child's sake and its own sake to give the child a moral chance at the earliest moment it is but little more trouble to regulate the crime-producing parent, at any rate to the extent of securing that the child's subsistence shall be paid for, or the work of undesirable parents be sequestrated so that no more unkept children may be born of that stock

The true remedy for a large amount of normal crime in short, is in cutting up the supply by the roots and the seed-bed is the home where parents who are criminal in mind live and rear their like Such homes in the main, are perfectly well known and if tuberculous people are registered for their own advantage and for the public protection, criminal tendencies through moral laxity should equally be registered and guarded against.

Are We to Leave Crime by Birth Its Fountain-Head Uncontrolled?

There would be no loss of self-respect for all such families are already under the law, and brigading them and taking care of their self-supported children, would have a fine tonic effect The alternative is to leave open and uncontrolled the fountain-head of ordinary crime A time will come when someone in public life will be bold and honest enough to say that those who are unfit to have the rearing of children in their hands shall not have it but that the State shall undertake that duty, and meantime, since they have children they are not fit to rear they shall, if necessary, themselves remain in pawn to the State for their children's maintenance Such a treatment of crime at its source would need no inquisition for the names of the families are already "writ large" in all the annals of local law and administration

At present however nothing of the kind is done or if thought of is only whispered about timidly so we have to pass on to the legal palliatives in force after children have already been more or less infected A great deal undoubtedly has been done wisely in recent years to keep young people out of crime the operative aims being to prevent contact with the confirmed criminal, and to establish a sense of self-respect in the delinquent Admittedly there is a stage of criminality beyond which redemption is barely possible Eighty-five per cent of *old* offenders come back to prison On the other hand the authorities of the great American reformatory prison of Elmira declare that "up to a certain age the criminal may be potentially regarded as a good citizen" Let us see what safeguards have been introduced before that age

Efforts to Prevent Further Contamination of the Young who are Going Wrong

The fear of all who have any contact with the young who break the laws is that they should be enrolled in the ranks of crime To prevent that various devices have come into use and each serves a good purpose Thus there is the probation device A wrong-doer who is making a first appearance in the courts and whose past gives ground for some hope that his arrest will be a warning to him is put on probation for six months or a year and is watched and advised by an experienced officer of the court In this way good impulses are fostered and bad influences are discounted A similar device which is often used in England, but is particularly associated with Belgian justice, is the deferred sentence The pronouncement of the law against the offender is held over for a period and is never made if conduct proves satisfactory This combination of suspense with hope has proved a salutary method of reform, and has given the delinquent the stimulation towards uprightness in which he was naturally deficient It has been said truly that "reflection is feebly represented in the criminal mind," and probationary periods and suspended punishments are useful in prompting reflection, till they may even give a promising start to good habits.

In the cases of certain types of young offenders, and certain offences, a good deal may be said for corporal punishment. It is not an unnatural punishment for boys. They can understand it and its relevance to the offence, and it does not leave behind the mental bitterness that superfine people would read into it for themselves. Moreover, a few strokes with a birch rod are more feared, both by bad boys and their indulgent and ruining parents, than any other punishment. When it is over it is done with, except as a deterrent reminder; and in later years almost every lad, with an element of manliness in him, will admit that he was all the better for a smart thrashing which he richly deserved.

The Place in Remedial Work of the Industrial School and the Reformatory

It may be said this is a primitive method. But the lawless boy is a primitive creature, and does not judge things with the thoughts of the reflective and unadventurous man.

For those who must be dealt with in youth for repeated offences, and, above all, be separated from their home surroundings, the industrial school, or, in more persistent cases, the reformatory, is an inevitable stage towards recovery, or towards hardening. The supreme difficulty of the reformatory is in forming a sound spirit of manliness among so many whose general level of mind and character is low. With difficulty can any community rise above the moral average of its members, unless there is a dominating personal influence at hand that counts more than numbers. The ordinary reformatory witnesses a strife of influences—the action of a few bad and rebellious spirits on a low level of intelligence, and against that the power of routine, work, and a varying degree of moral elevation in the staff. On the whole, considering the human material, and the preliminary spoiling from which it has suffered, the reformatory produces a reasonable amount of reformation.

The Evil of Imprisonment as an Alternative to Paying a Fine

The industrial school and reformatory are the instruments by which Society endeavours, in this country, to train towards citizenship the young who were beginning to sink into crime; but what of those who offend when they are older? Children cannot be admitted to an industrial school over fourteen years of age, or be detained there after they are sixteen. They are admitted to reformatories up to sixteen, but cannot be detained beyond nineteen. The beginnings of punishment at a later period—besides probation and deferred sentences—usually take the form of fines, with the general weakness that a fine is commonly enforced by an alternative sentence of imprisonment. The magistrate does not intend that the imprisonment shall take effect; it is only a lever to ensure the payment of the fine. But in too many cases, without any further consideration or adjudication, the alternative imprisonment is incurred, and the character of the delinquent receives a stigma from which recovery is difficult. For in the proportion that Society is escaping from imprisonment on false grounds for sham offences, the disgrace of imprisonment is deepened. The readiness with which imprisonment is dispensed as an alternative to fines is one of the backward features of our modern treatment of crime. An unintended push over the doorstep of the prison may amount to a social wrong. Often it is the police, and not the magistrates, who by their handling of the prisoner decide, practically, whether he becomes a gaol-bird. The matter is left in their hands, and by a little judicious management they might collect the fine, as the court intended, where they do not.

The High Value as Punishments of Wisely Fixed Fines

The value of the wisely fixed fine as an introductory punishment is unquestionably great. We say "wisely fixed" because there is a tendency in the case of certain benches of magistrates, when dealing with some offences—as for example, breaches of the Game Laws—to impose fines which almost compel imprisonment. Obviously a fine must be proportioned to the means of the offender, for what would be a trifle to one delinquent might be ruinous to another. An objection advanced against fines is that they too often punish the innocent families of the wrong-doer as much as they punish the wrong-doer himself. Parents pay for their children; wives and children suffer with the erring father. But this inevitable spread of sorrow is one of the secrets of the deterrent influence of the fine. The man sees part of the effect of his misdeed hurting the section of society nearest to him—his family. If he could see a little farther he would feel the mistake of doing wrong because of its ill effect on the whole community.

We now pass from the young whom we have allowed to become infected; from the beginners in crime whom we have attempted to cure, in and out of our institutions; from the casual offenders who

have been made to pay in acknowledgment of their misdeeds—though we have no system, as the Swiss have, of making them work out their debt of damage to the community—and we come to the serious and perplexing problem of the more or less confirmed criminal, who returns again and again to prison, until, indeed, in many cases, he regards the gaol as his normal home, where he is more at ease than anywhere else in the world. Outside, he has lost his place among men. Perhaps, even, he never had a place sanctioned by the world. Forty-five per cent. of the men who enter our gaols find their way there again, and 60 per cent. of the women. What can be done with them?

Every form of harshness has had more than a full trial in prison treatment. Now, the high-water mark of severity is solitary confinement, in silence, without human intercourse. Originally the cellular system was a reform from indiscriminate herding in gaols, but its power of punishment soon became apparent. Unquestionably there is no more certain way of breaking a man up, body and soul, than leaving him aimless, by himself, without any human companionship, on a lowering diet, and haunted by a sense of degradation.

The Only Use of the Dreadful Punishment of Solitary Confinement

That way lies insanity if the punishment be urged to an extreme; and if long continued under any circumstances it takes out of a man such manhood as may have been left to him, and unfits him for contact with the world. This form of punishment turns upon a total suppression or obliteration of personality, though the creation of personality is the only hope of reform. Nothing but a keen sense of sustaining right will preserve character from disintegration under solitary confinement; and it should be kept as a rare punishment to be dreaded by the most recalcitrant, as birching is dreaded by the young.

It is generally agreed by criminologists that first punishments in gaol should be short and sharp, and should cause the worst features of gaol-life to be felt, so that prison may be regarded instinctively as an undesirable place. Its punitive character may no doubt in this way turn back some. But the men of confirmed bad character know from the first that, the longer their sentence, the better will be their treatment, and so a tendency is created to commit serious offences that will carry the prisoner forward into the ameliorative stage of treatment.

There can be no question as to the bad effect of short sentences, casually given, and involving no severity of punishment. Such sentences manufacture criminals, by accustoming them to prison under the most favourable circumstances, and, instead of being easy punishments, are in reality ruinous. For that reason it is of great importance that every magistrate should be an observer and, indeed, a student of prison treatment and effects. The only hope for the man who is definitely drifting into the criminal class is that he shall be given a sentence long enough to allow remedial influences to have a fair chance.

A Hopeful Remedy which English Opinion Does Not Accept

To this end a large number of thoughtful criminologists favour what is called the indeterminate sentence; that is, a sentence which allows the release of a man sooner or later according to the remedial effect of the imprisonment on him, and his presumed readiness for life outside, otherwise than as a criminal. It is pointed out that the indefinite duration of the term of withdrawal from the world is a stimulus. It gives hope, and provides an aim. Its object, from the point of view of the authorities, is the benefit of the wrong-doer, not his punishment. It enables them to complete a course of training that may be essential to the earning of an honest living. On the other hand, the indeterminate sentence has not secured spontaneous assent from British opinion, but seems to offend our instincts, which—perhaps short-sightedly—demand so much punishment for so much offence, and dismiss the remedial view. The serious objection is that it throws great responsibility on the prison authorities in making them permanent arbiters of men's fate, and it presupposes that there *is* a genuinely effective remedial system humanely and successfully carried on.

The Difficult Task of Industrialising Unpromising Human Material

To the working out of such a system a great deal of attention has been given, particularly in England and the United States. The most talked-of experiments and methods are those of Elmira, in Pennsylvania, under Mr. Brockway, which, however, have not escaped severe criticism. As much has been done in this country with less publicity. The secret of remedial imprisonment the attempt to save the

man, if possible—is in industrialising the prison, and in making life there a preparation for life outside, instead of being a process of unfitment, as was the case with strict cellular imprisonment.

Inherently the work is difficult in the highest degree. Both the material and the means of working are eminently unpromising. All records show that the average criminal exhibits humanity on a low level. He has not been trained to habits of industry; his physique is poor, as a rule; he hates work; he sees little hope, for he knows that outside he is a marked man without a character; and as his whole life's aim, in many cases, has been to live by cunning, his prison tendency is to use that cunning to impose on, and please, the prison authorities by seeming to fall in with their aims rather than to master genuinely the means whereby a living may be won. The human material to be moulded under these conditions is poor, it is unwilling, and it should not have existed.

The Difficulty of Changing the Staff Traditions of Prison Life

Then, too, the means for manipulating this material are unaccommodating. The whole tradition of prison life, from both the sides of the prisoners and of their guardians and superintendents, is hampering. An atmosphere of long formation cannot be swept away by order. Besides, discipline must be maintained, exactness demanded, contamination by the wholly vicious prevented; and the prisons are peopled not only by the social wastrels whose birth and rearing we have been describing, but by criminal abnormalities, and by casual offenders of every kind, the "sports" of the unmoral. Contact with this mixed mass of miserable human nature moulds the official mind: and the conditions of work, of teaching and learning, are inevitably widely different from those existing in the free, ambitious, competitive world of natural industry. Can we wonder if, under these circumstances, solid remedial work in prisons seems slow, and many incorrigibles are left unaffected?

Redemptive Prison Work a Measure of the Progress of Civilisation

In this difficult work of the redemption of Society's outlaws much more help might be given than is given by the general public. There should be a readier co-operation in finding suitable employment for the men who, through a prison training, have reached a substantial hope of living as useful citizens with a command of some trade. And, above all, the general public should understand and sympathise with human recoveries, and make the way easy for them instead of impossible. It is bad enough that such men must always wear a scar; there is no need to open the wound.

The difference between the spirit which seeks thus the redemption of the man who really is guilty of warfare against society, and the spirit that, less than a hundred years ago, was pronouncing terrible sentences for cruel execution against people who had committed quite minor offences, measures well the progress made by civilisation in the nineteenth century. And the new spirit is proving effective. Notwithstanding the coming of fresh crimes, and fashions in crime, with changing civilisation and scientific progress, and the failure, hitherto, to grapple firmly with the question of the supply of youthful offenders from the criminal and semi-criminal stocks, there is a notable decrease in the aggregate of prisoners; yet there remains an incorrigible residue, and to them our last comments must be given. What should be done with the men who without a shadow of doubt are criminal in instinct and habit, and will remain so to the end of their lives?

The Lasting Problem of What to Do with the Incorrigibles

There are thousands of such men in the country, in and out of gaol. The police watch when they come out, and know perfectly well that fresh depredations will begin, and the training of gangs of younger outlaws will be quietly set on foot.

Now, what rational argument can be advanced for the release of these men into a freedom to do wrong which will at once be utilised? Why can we not face the question of the incorrigible, as we must face the question of the insane, and ought to face the abounding evil of prolific feeble-mindedness? Why can we not say these men shall be treated as men, with considerate justice, not like kennelled hounds, but they shall not be set free to demoralise others and give a start to fresh crops of crime? They shall be given as much restricted freedom as is consistent with earning their living and securing personal advantages of a kind they can appreciate, as, for example, a friendly pipe or game at cards, in guarded companionship with such of their fellows as are proof against moral injury; but liberty to do harm—no. In various ways Society has to take a firmer grip of the true idea of liberty—including the restraint of liberty of the unsaveable criminal.

THE CARE OF DEFECTIVES

Problems which are Forced on Mankind by Hereditary Insanity and Hereditary Feeble-Mindedness

NEGATIVE EUGENICS IN PRACTICE

THE first and most tragic part of the problem of eugenics is furnished by the insane. We approach it with the new knowledge as to the inheritance of the insane "diathesis," or tendency, which the American Eugenists have lately obtained. As a preliminary, we distinguish, as in a category apart, all those cases of insanity which are definitely due to external accidents, such as injury, for they do not concern us, being non-transmissible.

But this is easier said than done, for every advance in the study of insanity adds to our appreciation of the natural or genetic factor in its causation. Alienists recognise an "influenzal insanity," a "puerperal insanity," which follows childbirth, a "lactational insanity," associated with the strain of excessive nursing, and an alcoholic insanity. But, as their inquiries proceed, they realise that, on the whole, there is, and must be, some very real and "natural" distinction between the people who get influenza, the women who produce and nurse children, the drunkards who *do* become insane and the certainly more numerous company who, under similar conditions, do not. So startling does this discrepancy appear that alienists get more and more into the habit of describing, say, influenzal insanity as due to the action of the influenza toxin upon a predisposed nervous system. They justly teach that, in describing the causation or, as it is technically called, the etiology– of these diseases, it is necessary to name two sets of causes, (a) predisposing and (b) exciting; and they put down "heredity" as the predisposing cause, while the exciting cause is the alcohol, the influenza, or the strain of nursing.

The more profound students of insanity have long argued in this sense, as against the common view, which simply ascribes the disease of the mind to "worry" or "drink," or what not. Dr. Henry Maudsley is specially to be named among those who have insisted upon the importance of the hereditary factor– *e.g.*, in cases of suicide among children. Modern inquiries support this view, not least when "family histories" are taken as seriously and thoroughly as they should be. Hitherto, the physician in charge has taken notes on this subject by way of a conventional preliminary, which might possibly be of interest. We see now that a really adequate study of the pedigree and stock of the patient is an essential to accurate diagnosis, and therefore to correct and useful treatment. Above all has this been suggested by recent attempts which have been made in this country, unfortunately without any Mendelian system, to collate the inmates of one asylum with those of another. Such attempts have shown that the inmates of any given asylum have an astonishing number of relatives in other institutions cousins, first, second, and third, for instance. The ordinary taking of the "family history," with reference to parents and grandparents, and uncles and aunts - where the inquirer was exceptionally painstaking - could not reveal the facts. The patient or patient's relatives were not even acquainted with the facts of, say, second-cousins, had they been asked for. But when we begin to get an inkling of them, because, perhaps, another inquirer, in another part of the country is in touch with us, and the name of the patient is unusual, and occurs in his field of study too, then the true nature of the problem appears.

The immediate need is evident. Probably legislation is less required than a revised form of administration. Much is to be hoped, and demanded, from the Lunacy Commissioners in the near future. They and the public and the medical profession must begin to look upon the insane population

of the country as a whole, more closely related than are the rest of the population; or, to put it another way, compared of far fewer stocks in proportion to their numbers. The fact that these unfortunate people are in various institutions must no longer interfere with our understanding of the problem. There must be a complete and accurate national register, in some form or another, of the insane population of the country. If a brother is in an asylum in London, and his sister is in an asylum in Edinburgh, the fact must be known. It is simply the application of the principle of census-taking to a very special and important purpose. The chief objection to it depends upon the brutality and ignorance with which, even now, the public at large looks upon insanity. Not all of us, as boys, have had the advantage of a mother who, when we referred to a lunatic's attendant as a "keeper," rebuked us in terms so scathing that the offence could never be repeated in a lifetime. So long as the public looks with ignorant contempt upon insanity, so long will the truth about it be hard to ascertain, and so long will the problem remain with us.

The Public Need for a Comprehensive Survey of Insanity

But the time has come when the mass of national *data* regarding the insane, which can be obtained, and is to some extent already obtained, in our asylums, must be gathered together, in competent hands, and properly collated. The facts that emerge will go far to remove the cruel prejudice under which the insane at present suffer. The result will be that our charity, in regard to the insane, will become at once more charitable and more efficient. Our standard of care will rise, for public opinion will sanction an adequate expenditure for that purpose, but at the same time it will demand, once the facts are known, that our care shall be made more careful.

In the bravest and most important utterance which has fallen from a high ecclesiastical dignitary for many a long day, the Archbishop of York told the Royal Sanitary Congress in July, 1912, that he was in favour of an amendment of the law "providing that marriages should be declared null and void if, within a certain time, it was shown that facts had been withheld disclosing insanity, epilepsy, or venereal disease." No less important is our duty in regard to persons, perhaps long married, who become insane, and are found to belong to an insane stock. It has already been pointed out in these pages that such persons are now only too often discharged from asylums during brief periods, until the conditions of existence outside cause the reappearance of the insane symptoms, and that meanwhile such persons may become parents, with terrible consequences to future generations.

Here, also, as in the circumstances referred to by the Archbishop of York, public opinion must be educated, with a view to legislation. At present the law is wholly in favour of dysgenics in this respect. The horrible facts which existed, and were at length disclosed, not very many decades ago, led to legislation such that the asylum authorities now have no choice whatever but to discharge patients who display no insane symptoms.

The Problem of the Patient whose Symptoms are Quiescent

It all depends upon the definition of such symptoms. Under the most favourable conditions, with no strain, no responsibility, a regular life organised by others, and no alcohol, the patient may exhibit practically no symptoms. If you will, he is "cured," must forthwith be discharged, and the annual report of the institution will look none the worse. But any real test, such as doctors apply to other forms of disease, in order to see what symptoms are evoked, would show in most of such cases that the patient is still insane, as indeed he speedily proves himself to be when he returns home. Undoubtedly we require such conditions that the patient whose symptoms are quiescent—for that is all it means in too many cases—shall not be able to obtain damages from an asylum superintendent if he is not immediately discharged. By all means let there be every safeguard against abuse, let there be facilities for "second opinions," and so forth, as freely available for the poorest as for the wealthiest patient—this is national business, concerning all of us, like the Navy or the Post Office and let the public be willing to incur extra expense, with the sure knowledge that, by taking better care of the insane we have, there will be far fewer of them to take care of in years to come.

The Necessity for Dealing with the Relations between Insanity and Divorce

About the time that these words are published, we may expect the Report of the Royal Commission on Divorce, and meanwhile the subject has to be mentioned without reference to the terms of that report—or those reports. But one of the subjects with which the Commission has to

deal is the relation of divorce to insanity. Here, as elsewhere, the witnesses have differed from each other to an extreme degree, but there can be no question as to the preponderant opinion among those who have immediate knowledge of the subject. Most of the courses open to mankind have disadvantages, and the ancient advice is that of two evils we should choose the least. But large numbers of people are callous or blind regarding the evils of existing courses, while preternaturally sensitive to the evils of any alternative.

Divorce is a lamentable thing in itself. It is deplorable that a man should prove to be incurably insane, and that his wife and children should find themselves in such a plight. It would be hard that a man who proved to be insane should also be in danger of being divorced from his wife. But it is much harder that the same wife should not be allowed to remarry, though her husband may have been sent to an asylum a few months after they were married, and remains there for thirty hopeless years before he dies; and it is even harder still that he should return to her, while in the "cured" state, and then proceed, under the influence of homicidal mania, to kill her and their children, or, which is almost as bad, to beget another child, with a destiny that is terribly certain to be tragic.

The Duty of a Study of Pedigrees Before Marriage

In all these instances the original cause of the harm and the misery is the insanity of the insane person; and the duty of a sane nation is to deal with its cause by trying to reduce as far as possible the number of insane persons in the community. This is the really kind, pitiful, humane, and tender course; and the granting of divorce for insanity, under certain stringent and carefully considered conditions, is clearly a means to that end.

Meanwhile, private people are not lacking in ample means of protection, nor without a duty to themselves and the future. It is the duty of each of us to become acquainted with his or her own pedigree, and the qualities of the stock, so far as that is possible; and when marriages are contemplated further inquiries must be made, not merely in the interests of eugenics, but from the point of view of the individuals as individuals, and of the marriage as a personal relation. Posterity, looking back upon us as we look back upon the dark ages, may regard, as the most refined and monstrous cruelty of our own age, the fashion in which we link young people together for life, without knowing or caring what we do, and without giving them any opportunity of learning for themselves.

The care of the actually insane involves exclusion of the possibility of parenthood, so long as it lasts. While cared for, they are segregated. The problem for negative eugenics is solved to that extent. But unfortunately there are large areas of the problem which that does not cover. Three of those areas must be observed, and then we have to ask ourselves what is to be done for them. They are, first, the period during which, in many cases, the person who is destined to become insane is at large, his condition unsuspected, and he thus becomes a parent, whether married or unmarried.

Diverse Problems that Arise in the Mating of Questionable Stocks

Here is something which needs remedy, and none the less so if a better knowledge of the pedigree of the individual would warn him, so that a carefully chosen and conducted life might prevent the hereditary tendency from ever showing itself even in him. Here is a benign aspect of these genetic studies and eugenic demands to which most of our critics are blind. Second, there is the problem of the insane patient who has a quasi-normal period, during which he does as he pleases; and, third, there is the problem of the individual, himself normal, but an "impure dominant" as regards the Mendelian recessive which we call the insane or neuropathic tendency.

What is to be done with these parts of the problem, which, between them, constitute so much of it, and neglect of which must certainly mean its perpetuation for future generations? The only definite answer we can return is that segregation compelled by law is simply out of the question as a complete solution. The alternatives are only two—voluntary control, if and when that is possible, or sterilisation.

The Surface Resemblances but Real Differences Between Insanity and Feeble-Mindedness

We must look at these possibilities more closely when we have dealt with the second great category of those for whom the principles of Negative Eugenics are urgently required—namely, the feeble-minded.

There are, of course, certain points of resemblance between insanity and feeble-mindedness or mental defect, just as there are certain points of resemblance between, say, infantile paralysis and the paralysis of apoplexy. Thus, for instance, in many

forms of insanity there is a progressive deterioration of mind, so that the patient becomes demented, and in this condition of "terminal dementia," as even in certain forms of "senile dementia," there is bound to be a considerable psychological resemblance to feeble-mindedness. The person who has lost the mind he once had is not unlike the person who never had a mind to lose—that expresses the facts in popular language. But this resemblance between dementia and amentia, to use the technical terms, must not blind us to the real distinction between insanity and feeble-mindedness. The chief obvious distinction between the two, from the outside, is that feeble-mindedness shows itself in the course of development; *the mind does not appear.* Or, rather, it does not sufficiently appear. In extreme cases, which we call idiocy, the mind is almost wholly absent; in imbecility less so, and in the higher-grade imbecile and the feeble-minded the defect is of still less degree. But these are all grades of the same thing, so far as we can judge them psychologically.

The idiot and the imbecile scarcely concern us here, for their condition is so severe and their helplessness is so great that they raise no eugenic problems. With the feeble-minded the case is otherwise. Though feeble-minded, they are fertile-bodied.

The Tragic Tendency of the Feeble-Minded Towards Prolific Propagation of Their Type

In certain ways they can maintain a miserable existence in the open world—the women especially by leading a life of shame, and the men especially as tramps. They tend to consort with one another, naturally enough, because whole-minded people prefer the whole-minded. Thus they become parents; and in a large proportion of cases both parents of the child are feeble-minded, with the inevitable result. But before we make this assertion as to heredity, or are entitled to quote the work of Goddard and Davenport and others in America, as to the genetics of this defect, we must be very sure that we recognise the all-important distinction between the genetic and somatic cases—the true feeble-mindedness of those in whom the defect is inherent, and the pseudo-feeble-mindedness—if such a term may be permitted for once—which imitates the genetic defect, and may display, for a time, the same symptoms, but is nevertheless distinct in origin and in consequence.

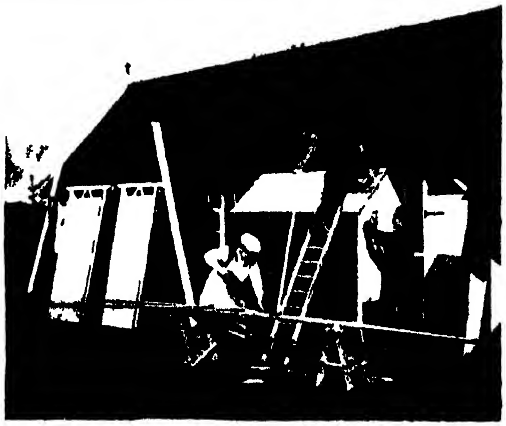
The conditions of mind which imitate true mental defect are by no means so numerous, nor so constantly hard to distinguish, as amateur critics suppose. But they exist, and must be well understood. We saw that senility or long-continued intoxication (with whatever nerve-poison) might produce a sort of mindless condition, late in life, which was not unlike that of a mentally defective child. Similarly we are to know that similar improprieties of *nurture* may so interfere with the mental development and capacity of a child that it may seem to be *naturally* defective in mind.

The Important Difference Between Inherited and Nurtural Backwardness

Perhaps the child has merely had a run of bad luck—measles, whooping-cough, scarlet fever, in quick succession. Its schooling has been interfered with, and, worst of all, perhaps it has been left somewhat deaf—or very deaf, alas! Or the child has been systematically bullied and neglected by drunken parents. It lives in a state of perpetual fear, for whenever it has opened its mouth it has been struck. It is reckoned that half a million children in Great Britain are at any time the victims of chronic cruelty. Or the child has been unsuitably fed, perhaps with too little food, perhaps with the wrong kind of food; and it has not had enough of the right kind of sleep, or exercise, or warm clothing. Or it has associated wholly with selfish adults, and has had none of the right kind of young company. Now, take such a child, aged, say, seven years or ten, and compare it with a class of more fortunate children of the same age. The child is, of course, "backward," but, worse than that, the child is "dull." It not merely does not know, but it cannot learn. And that is the mark of the feeble-minded child. Therefore we may be liable, unless we are experienced and patient, to put this child into the category of the truly feeble-minded, whereas its condition is essentially accidental.

The Response Made by the Child that is Only Nurturally Backward

The importance of this distinction is twofold. In the first place, the child whose condition has no genetic basis is not to be feared from the point of view of genetics or eugenics. It can no more transmit this accident imposed upon its bodily or somatic development from without than it could transmit a similarly acquired scar upon its scalp. Whatever, therefore, is our duty to this child, to interfere with its possibilities of parenthood on the ground of its personal condition would be wrong.



CARPENTRY, LAUNDRY-WORK, AND AGRICULTURE AS CARRIED ON AT THE PRINCESS CHRISTIAN'S FARM COLONY FOR THE FEEBLE-MINDED

In the second place, the child whose mental condition is nurtural will respond to better nurture, and become normal, perhaps not so strong in mind as it would have become under conditions good from the first, but whole-minded nevertheless. Not only is this fact welcome in itself, but it is invaluable as an indication of our duty to children whose minds are below par, for it furnishes us with the one and only infallible means of what in medical language is called *differential diagnosis*. We can differentiate the two kinds of children from one another by the test of treatment. The child that responds is a case of merely imitative feeble-mindedness; the child that does not has the veritable defect. Of course, this does not mean that, say, in the home near Manchester which Miss Dendy and her helpers look after, the feeble-minded girl is not better nurtured, and even less feeble in mind, than if she had been allowed to become a street-walker and inebriate; that should go without saying. But what we have asserted stands: and all who have any first-hand knowledge of the subject, above all the devoted and ill-rewarded teachers in our special schools for defective children, are familiar with the crucial and diagnostic difference between the response of the veritable and that of the imitative case to improved conditions of nurture—dietetic, educational, and all other kinds.

The Incurability of Feeble-Mindedness the Central Fact About It

This fact must be insisted upon with all the force at our command. It is the sole fact that constitutes the practical difference between the two sets of cases; and upon our recognition of it depends the possibility of applying our knowledge and our humanity to the problem, so that the imitative cases may be cured, and the veritable cases may be cared for.

Here we come to the central fact of which it is so hard to persuade the very numerous people who entertain strong opinions on the subject without having seen, or making any attempt to see, anything of it. It is that the condition of the veritable feeble-minded is incurable. It has a similar biological or genetic origin to brownness or blueness of the iris, redness of hair, hairiness of chin, fineness of fingers or toes. In the nature of the case, it is not curable. But where we cannot cure we can care. We can protect the unfortunate from the consequences of their defect; and, of course, *our care will require to be maintained as long as the need for it exists.* Further, the primary and sufficient need for this care has nothing to do with eugenics. If all these patients were mercifully sterile, their personal need would still be the same. The alternatives are simply care or neglect of those who need care as children do, but who need it longer, because, in many important respects, though unfortunately not in the most enduringly important of all, they are children all their days.

In this country at the present time we have certainly not less than one hundred and twenty thousand of such unfortunate people, and their number is certainly increasing. Some years ago the number of special schools in London alone, where they are cared for, reached eighty-four, and the number of mentally defective children in the metropolis is about seven thousand.

The Admitted Futility of the Present Method of Dealing with Defective Children

Our present method of dealing with the problem may be simply stated. We take care of the children until they reach the age of sixteen. On that day the law declares that they must be allowed to do whatever their parents or natural guardians please. We can no longer do anything for them until they reach the police-court. We seldom have long to wait. Each feeble-minded child, while at school, has cost approximately as much to educate—and it cannot be educated—as six normal children. All of this we pay cheerfully, happily oblivious of the fact that a few years later the child, if she be a girl, will probably be on the streets—for which destiny, presumably, we are educating her—or, whatever the sex, in the police-courts for being drunk and disorderly.

A highly qualified correspondent has kindly made inquiries in Germany, on behalf of the writer, and the result of them may conveniently be cited to show what is actually done there, and then we may proceed to consider the possibilities here.

Good and Bad Points in the German Treatment of Defectives

It appears, according to this recent information, that the feeble-minded in Germany are kept under proper supervision either in private or in State homes, and are taught a trade, so far as may be, as in the very few institutions of the kind in this country. When the case is considered suitable, the patient is boarded out with peasants, where he (or she) can pursue his trade, thus partially supporting himself, meanwhile being under supervision. Those

who do not reach such a level of capacity are *permanently* cared for in various kinds of homes. Any feeble-minded youth who is guilty of a moral offence is severely punished —a most unjust and cruel law, unworthy of scientific Germany—and is for ever after kept under the strictest police supervision. No feeble-minded girl can become a mother, for she never has any opportunity of meeting the opposite sex. There are very few feeble-minded children in Germany.

Now for our own problem. Few have been more discussed of recent years, and the methods proposed are many and diverse. However frequently some of the least wise may be condemned and exposed, they recur in controversy. Let us be clear about them here. The "process of exclusion" is convenient here, and we may employ it.

Some Suggested Methods of Treatment that Must be Entirely Rejected

Accordingly, we shall here name, only to reject, the following: *The Lethal Chamber, the Permission of Infant Mortality, Interference with Ante-Natal Life, and all other synonyms for murder.* In a moral and rational community it should not be necessary to name such proposals nor to combat them, but we have no choice. Let us observe, then, that in dealing with the feeble-minded we have to discharge our duty to *all concerned* to the patients and to the community present and to come. Let us name and remember the patients first, for there is always the risk that they, as individuals, and the eugenic cause may be injured by would-be prescribers who have lost touch with first principles. Suggestions for "painless extinction," lethal chambers of carbonic acid, and so forth simply fail to see the whole meaning of eugenics, which has nothing to do with killing. Natural selection acts by death, but eugenic selection by birth. We propose to replace a selective death-rate by a selective birth-rate; eugenics is selection for parenthood, not selection for life. No form of legal or constructive murder (such as the permission of infant mortality) is to be tolerated here, for all these proposals miss the vital point, which is the distinction between the right to live and the right to become a parent.

The Unanimous Rejection by Public Opinion of all Mutilative Proposals

One other proposal must be condemned outright, as cruel, dangerous, and unnecessary, and that is mutilative surgery for the sterilisation of the feeble-minded. Non-mutilative sterilisation, involving no injury to the individual's entirety, is an entirely different question. The two proposals must be kept distinct; and the only criticism which it was possible and necessary to make in regard to Mr Van Wagenen's valuable paper on sterilisation at the 1912 Eugenics Congress was that the profound distinction, moral and practical, between sterilisation pure and simple, and sterilisation dependent upon emasculation or defeminisation of the patient was not clearly drawn and maintained. Opinion at the Congress was, however, unanimous, when attention was drawn to the point, that this distinction must be maintained. Here, therefore, we definitely repudiate all mutilative proposals, and may further add that no responsible Eugenist makes or has made them.

Another suggestion which sounds reasonable enough need only briefly be referred to. "They must not be allowed to marry," is how it runs. The Mental Deficiency Bill, in Committee of the House of Commons at the time of writing, makes it an offence to marry a feeble-minded person. Doubtless this is right and as it should be. But no one who knows anything of the lives of the feeble-minded can imagine that this suffices. To forbid marriage, on grounds of negative eugenics, to persons who still live in and as part of the community is to court many kinds of disaster, and it is most certainly not to interfere effectively with their parenthood, as the records of illegitimacy prove.

The Many Ways in which the Feeble-Minded Injure the Whole Community

Where we have grandmother, daughter, and grandchild all feeble-minded and all illegitimate, under the same workhouse roof, "refusal of permission to marry" seems rather inept a remedy for the problem.

Apart from the question of sterilisation, there remains the remedy which is technically known as segregation, and by which is meant permanent care and treatment, under humane medical supervision, primarily in the interests of the persons who require such care. Few proposals of our time are more frequently misunderstood and misrepresented. In order that we may see to what this is the alternative, there may here be quoted a portion of the paper read by the present writer to the National Conference on the Prevention of Destitution in 1911.

"The mentally defective and diseased, existing in it and as part of it, injure the community in the following ways.

"(1) They contribute largely to the ranks of chronic alcoholism and inebriety, with all

their consequences—for the description of which, despite the cheap and common gibe, the language of no temperance reformer can very well be intemperate.

"(2) They contribute largely to the illegitimate birth-rate; that is to say, to the production of children for whose nurture, quite apart from the question of their natural defect, no adequate and satisfactory provision is or indeed can be made.

"(3) They contribute largely to the ranks of prostitution.

"(4) They thus contribute largely to the propagation of the venereal diseases, with all their consequences to the present and the future.

"(5) They are responsible for much crime, major and minor, both *mala in se* and *mala prohibita*—things wrong in themselves and things forbidden.

"(6) Both directly, as economically inefficient, and indirectly, in the ways here cited, they contribute to the number of the destitute, constituting the majority of the naturally, as distinguished from the nurturally, unemployable.

"(7) They contribute largely, as parents, married or unmarried, to parental neglect and cruelty to children, which is probably more injurious to the life of the next generation than most or any of us realises.

"(8) They contribute largely to the ranks of the wastrel and the hooligan.

A Humane Segregation the Alternative Policy to the Continuance of These Evils

"In such ways and to such a degree these persons injure the community. But it has particularly to be noted that therein the community also injures them. The fact is obvious to all of us here; but it is by no means obvious to our vocal and voluble critics outside, who fancy that we are preparing harsh measures, in the interests of the many, against the unfortunate few who cannot help themselves. The injury wrought by the present relations between the community and these unfortunate persons is mutual—they injure it and it injures them. But not until we recall the words of Burke, in the light of modern genetics, shall we realise the full measure of this injury; for, as that great thinker said, a community is a partnership not only between those who are living, but between those who are living, and those who are dead and those who are to be born.

"To the foregoing indictment of the present state of things, and remembering that whatever is inherent is transmissible, we therefore add that—

"(9) In becoming parents, the feeble-minded contribute incalculably to the maintenance of these evils—after we are dead, but not after we are responsible."

These are the evils for which the policy of segregation is the alternative—segregation of the victims of such mental defect and disease as is known to persist and be transmissible. We definitely put the interest of the individual patients first; and we demand proper care for the feeble-minded woman of sixty as well as for the girl of sixteen. True, what we ask is not only the discharge of a humane and imperative duty to the individual, but also involves, in the latter case, the protection of the future, only we must be very careful to put these two objects in their proper order.

The Need for the Phrase "Permanent Care" Because of the Odium Cast on "Segregation"

But, unfortunately, many persons are now advocating the "segregation of the feeble-minded" in a fashion which leads the kind-hearted, and the champions of what they understand by liberty, to suppose that we wish to run these unfortunate people into prison-cells and leave them there. Hence, after many years of reiteration with voice and pen, of the demand for segregation, the present writer now pleads only for "permanent care." They are the same thing, but public opinion, which will never grant the one, will readily grant the other.

The augument against segregation that it would be expensive is beneath our contempt here, and would be so even if the neglect of the feeble-minded were not so very much more expensive. In this peculiar science we assume that gold is for life and not life for gold. Of real importance is the argument that we cannot always identify those who should be segregated. But, where we are doubtful, we must hold our hand. Our business is to teach that segregation is not harsh, hasty, and irrevocable, but humane, deliberate, and flexible.

Education of the Public the Only Hope of Humane Reform

We have utterly failed if we have not persuaded the reader that our present neglect of the feeble-minded, when they can do most harm to themselves and others and the race—neglect following immediately upon our admirable care of them before puberty—is an intolerable crime, and that there must be substituted for it, without delay, some such humane and intelligent policy of permanent care as shall relieve the miseries and evils of the present, and largely prevent their recurrence in the future.